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EDITOR'S PREFACE

TO THE

NINTH EDITION.

The present edition of the following work is the result of a very careful and thorough examination of the former impression. I have not only gone over all the calculations, and corrected whatever numerical errors I could detect, but I have also been anxious to present the several steps of each arithmetical process in the most compact and improved form. Much numerical work is often thrown away by neglecting to take advantage of *cancelling operations*. I have often had occasion to notice this in the revision of the last edition: in the present I have taken care to introduce every simplification into the arithmetical forms that such forms admitted; and I have reason to hope that those who have hitherto countenanced this work will find it even more acceptable in its present improved state.

JUN 20 1901 Ralph Mac Neill Ly

310714

I would notice, in conclusion, that the Table of useful Numbers often required in calculation, together with their Logarithms, at *pages* 169 to 180 inclusive, which has been computed at considerable labour, will furnish particulars of interest and utility in many practical inquiries.

SAMUEL MAYNARD.

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APPENDIX.

Containing Mathematical Tables.

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I. Containing the circumferences and areas of circles, sides of equal squares, squares and cubes of the diameters, from $\frac{1}{8}th$ to 100 inches, feet, yards, chains, miles, &c., advancing by $\frac{1}{8}th$, and also the side of equal square, advancing at an equal ratio . . . . . [1

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THE

MILLWRIGHT AND ENGINEER'S

POCKET COMPANION.

EXPLANATION

OF THE SIGNS OR CHARACTERS MADE USE OF IN THE FOLLOWING WORK.

$=$ signifies Equality; as 4 added to 3 $=$ 7, denotes 4 and 3 added together are equal to 7.

$+$ signifies Addition; as $5 + 3 = 8$.

$-$ signifies Subtraction; *viz.* that the latter of the two numbers or quantities between which it is placed is to be subtracted from the former: thus, $5 - 3 = 2$.

$\times$ signifies Multiplication; as $5 \times 3 = 15$.

$\div$ signifies Division; *viz.* that the former of two quantities or numbers between which it is placed is to be divided by the latter: thus, $15 \div 5 = 3$: the divided quantity or number is called the Dividend, that which divides is called the Divisor. Sometimes the divisor is written under the dividend, with a line drawn between them; as $\frac{15}{5} = 3$.

: is to
:: as
: is to

denotes Proportionals, signifying that the numbers or quantities between which they are placed are proportionals: thus, 2 : 4 :: 8 : 16, denotes that the number 2 bears the same ratio to 4 as 8 does to 16, and is usually read 2 is to 4 as 8 is to 16.

( ) Parentheses are used to connect two or more quantities together into one: thus, $(3 + 5) \times 3 = 24$, denotes that the sum of 3 and 5 (which is equal to 8) multiplied by 3 is equal to 24.

3^2 denotes $3 \times 3 = 9$, or the square of 3.

3^3 denotes $3 \times 3 \times 3 = 27$, or the cube of 3.

$\surd$ denotes square-root; as, $\surd 9 = 3$.

$\sqrt[3]{}$ denotes cube-root; as, $\sqrt[3]{27} = 3$.

OF WEIGHTS AND MEASURES.

Avoirdupois Weight is the only weight made use of in mechanical calculations; and all metals, save gold and silver, are weighed by it: hence it is not requisite here to take any other into consideration.

				Fr. Grammes.
	1 Dram	=		1·772
16 Drams	= 1 Ounce	=		28·347
16 Ounces	= 1 Pound	=		453·544
28 Pounds	= 1 Quarter	=		12·699 kilog.
4 Quarters	= 1 Hundred-wt.	=		50·797 ,,
20 Hundred-wt.	= 1 Ton	=		1015·939 ,,

Note.—5760 Troy grains = 1 pound Troy; and 7000 Troy grains = 1 pound Avoirdupois: hence, 175 pounds Troy = 144 pounds Avoirdupois.

Or, Avoirdupois	*lbs.* ×	1·21528	= Troy *lbs.*
Do.	ounces ×	·9115	= Do. ounces.
Troy	*lbs.* ×	·823	= Avoir. *lbs.*
Do.	ounces ×	1·1	= Do. ounces.
Do.	grains ×	·03657	= Do. drams.
Also, Avoirdupois	*lbs.* ×	·00893	= Cwts.
And, Do.	*lbs.* ×	·000447	= Tons, *nearly*.

TABLES

Showing the relative Proportion between Foreign Weights and the Avoirdupois Pound.

1. FRENCH WEIGHTS.—DECIMAL SYSTEM.

1 Milligramme	=	·0154 Troy grains.
1 Centigramme	=	·1543 ,,
1 Decigramme	=	1·5434 ,,
1 Gramme	=	15·4340 ,,
1 Decagramme	=	154·3400 ,,
1 Hectogramme	=	1543·4000 ,,
1 Kilogramme	=	2·20486 *lbs.* Avoirdupois.
1 Myriagramme	=	22·0486 ,,
1 Quintal	=	1 *cwt.* 3 *qrs.* 24½ *lbs. nearly.*
1 Millier or Bar = 100 Quintals	=	9 *tons* 16 *cwt.* 3 *qrs.* 12½ *lbs.*

2. SYSTÈME USUEL.

The Kilogramme =	1000	Grammes =	2 *lbs.*	3 *oz.*	$4\frac{1}{2}$	Drs.	Avoir.
The Livre Usuel =	500	,, =	1 ,,	1 ,,	$10\frac{1}{4}$	,,	
The Half..... =	250	,, =		8 ,,	$13\frac{1}{3}$	,,	
The Quarter ... =	125	,, =		4 ,,	$6\frac{1}{2}$	,,	
The Eighth .... =	62·5	,, =		2 ,,	$3\frac{1}{4}$	,,	
The Once..... =	31·3	,, =		1 ,,	$1\frac{3}{4}$	,,	
The Half..... =	15·6	,, =			$8\frac{7}{8}$	,,	
The Quarter ... =	7·8	,, =			$4\frac{1}{2}$	,,	
The Gros ..... =	3·9	,, =			$2\frac{1}{4}$	,,	

3. VARIOUS FOREIGN WEIGHTS IN POUNDS AVOIRDUPOIS.

Places & names of weights.	*Lbs.*	*Places & names of weights.*	*Lbs.*
Alexandria { rotola forfora.....	·9367	Genoa ..... peso sottile	·6988
,, rotola zaidino	1·335	,, peso grosso	·7687
,, rotola zauro...	2·07	Hamburgh.....pound	1·068
,, rotola mina...	1·67	Havannah .....pound	1·075
Amsterdam ... old pound	1·09	Leghorn.....pound	·749
,, new ditto	2·205	Madras .....vis	3·125
Antwerp ..... old pound	1·033	Malabar .....visay	3 001
,, new ditto	2·205	Malta.....rotola	1·750
Bahia, Lisbon, and Oporto { aragal	1·012	Mocha.....rotola	1·125
Barcelona ..... pound	·882	Mogadore { commercial pound	1·19
Batavia ..... catty	1·36	,, market pound	1·781
Bergen		Naples .....rotola	1·964
Christiania, and Copenhagen .... { pound	1·1013	Odessa and Petersburgh { pound	·9026
Bombay .....seer	·7	Port-au-Prince and Port Louis { livre poids de marc	1·08
Bremen ..... pound	1 099	Riga .....pound	·9217
Buenos Ayres, Cadiz, Lima, Malaga, Valparaiso, and Vera Cruz..... { pound	1·015	Rio de Janeiro .....aragal	1·01
		Rotterdam.....pound	2·205
		Smyrna .....oke	2·82
Calcutta.....seer	2·053	Stockholm { commercial pound	·9365
Canton & Manilla ... catty	1·333	,, iron weight	·75
Cape Town ..... pound	1·09	Trieste .....pound	1·235
Constantinople ..... oke	2·83	Venice .....peso grosso	1·0517
Dantzic & Memel...pound	1·033	,, peso sottile	·6641

NOTE.—America, the British West Indies, Gibraltar, and Tasmania use the pound Avoirdupois, as in England.

EXAMPLE 1.—Suppose I purchase an article in London which weighs 50 *lbs.* Avoirdupois, what will it weigh in Amsterdam according to their new weight?

50 *lbs.* ÷ 2·205 = 22·676 *lbs.* of Amsterdam.

Ex. 2.—An article that weighs 60 *lbs.* in Leghorn, according to their weight, what will it weigh in *lbs.* Avoirdupois?

·749 × 60 = 44·94 *lbs.* Avoirdupois nearly.

LONG MEASURE.

				Fr. Mètres.
12	Inches	= 1 Foot	=	·3048
3	Feet	= 1 Yard	=	·9144
6	Feet	= 1 Fathom	=	1·8288
5½	Yards	= 1 Pole or rod	=	5·0292
40	Poles	= 1 Furlong.....	=	201·1679
8	Furlongs or 1760 yards..	= 1 Mile.....	=	1609·3436
3	Miles	= 1 League	=	4828·0307

Surveying Chain = 22 yards, consists of 100 links, and each link = 7·92 inches.

FRENCH LONG MEASURE.—DECIMAL SYSTEM.

French.		English.
1 Millimètre	=	·03937 inches.
1 Centimètre.....	=	·39370 ,,
1 Decimètre.....	=	3·93701 ,,
1 Mètre.....	=	39·37009 ,,
1 Decamètre	=	32·80841 feet.
1 Hectomètre	=	328·08408 ,,
1 Kilomètre.....	=	1093·61358 yards.
1 Myriamètre	=	10936·13583 ,,

SYSTÈME USUEL.

Usuel.		Metrical.		English.
1 Ligne .... =	2·31	Millimètres	=	·091 inches.
1 Pouce .... =	2·77	Centimètres	=	1·090 ,,
1 Pied ..... =	3·33	Decimètres	=	13·110 ,,
1 Aune ..... =	12	Decimètres.....	=	3 feet 11·24 inches.
1 Toise ..... =	2	Mètres	=	6 ,, 6·74 ,,

THE LINEAL FOOT OF VARIOUS COUNTRIES, GIVEN IN ENGLISH INCHES.

	Inches.		Inches.
Amsterdam & Antwerp.....	= 11·143	Canton	= 12·65
Bahia, Lisbon, and Rio de Janeiro..	= 12·944	Dantzic and Memel	= 11·3
Bergen, Copenhagen, Cape Town, Christiania, and Hamburgh	= 12·36	Port-au-Prince and Port Louis	= 12·8
		Riga.....	= 10·79
		Stockholm	= 11·684
		Venice	= 13·68

Note.—The English foot is used generally throughout America, the British West Indies, Russia, and Tasmania.

LENGTH OF A MILE IN DIFFERENT COUNTRIES, GIVEN IN ENGLISH YARDS.

	Yards.		Yards.
Dantzic	8475	Poland	8101
Denmark	8244	Portugal	6760
Flanders	6864	Prussia	8237
Germany	6859	Russia	1167
Hanover	11559	Scotland	1984
Holland	8101	Spain	4635
Hungary	9113	Sweden	11700
Ireland	2240	Switzerland	9153
Netherlands	1093	Tuscany	1808

SUPERFICIAL MEASURE.

				Fr. Sq. Mètres.
144	Square inches	= 1 Sq. foot	=	·0929
9	Square feet	= 1 Sq. yard	=	·8361
30¼	Square yards	= 1 Sq. pole	=	25·2928
40	Square poles	= 1 Rood	=	1011·7136
4	Roods, or 4840 Sq. yards	= 1 Acre	=	4046·8543

A Scotch Acre contains 6084 square yards,
And an Irish Acre contains 7840 square yards.

FRENCH SUPERFICIAL MEASURES.

1 Centiare	=	1·1960 square yards.
1 Arc (a square decamètre)	=	119·5991 ,,
1 Decare	=	1195·9907 ,,
1 Hectare	=	11959·9067 ,,
		or 2 acres 1 rood 35 perches.

SOLID MEASURE.

				Fr. Cubic Mètres.
1728	Cubic inches	= 1 Cubic foot	=	·0283
27	Cubic feet	= 1 Cubic yard	=	·7645
42	Cubic feet	= 1 Ton of Shipping	=	1·1892

A Load of unhewn timber	=	40 cubic feet.
,, squared do	=	50 ,,
,, 1 inch plank	=	600 square feet.
,, 1½ inch do	=	400 ,,
,, 2 inch do	=	300 ,,

NUMBER OF CUBIC FEET IN A TON OF VARIOUS BODIES.

Names of Bodies.	Cubic feet in a ton.	Names of Bodies.	Cubic feet in a ton.
Marble.....	13·06	Beech.....	42
Granite	13·5	Teak	48
Common Stone ..	14·22	Mahogany	34
Paving do....	14·82	Lignum Vitæ....	27
Sand	23·6	Maple & Riga Fir	47·8
Coal	28·6	Larch.....	65·8
Tallow	38	Pitch Pine	54·2
English Oak	37	Oil	39
American do.....	41	Proof Spirits	38·6
Ash	42	Distilled Water ..	35·8
Elm	53	Sea do....	34·8

A Gallon of Linseed Oil weighs ..... 9·32 *lbs.* Avoirdupois.
„ Distilled Water ..... 10 „
„ Sea Water ..... 10·32 „
„ Proof Spirits ..... 9·27 „

IMPERIAL WINE MEASURE.

	1 Gill ..... =	8·665	cubic inches.
4 Gills..... =	1 Pint .... =	34·659	„
2 Pints ..... =	1 Quart.... =	69·318	„
4 Quarts.... =	1 Gallon ... =	277·273843570	„
10 Gallons .. =	1 Anker ... =	1·604	cubic feet.
18 Gallons .. =	1 Runlet ... =	2·888	„
42 Gallons .. =	1 Tierce ... =	6·739	„
63 Gallons .. =	1 Hogshead =	10·109	„
84 Gallons .. =	1 Puncheon =	13·478	„
126 Gallons .. =	1 Pipe .... =	20·218	„
252 Gallons .. =	1 Tun .... =	40·435	„

FRENCH MEASURES OF CAPACITY.

1 Millitre.....	=	·06102 cubic inches.
1 Centilitre	=	·61024 „
1 Decilitre.....	=	6·10238 „
1 Litre (a cubic decimètre)	=	61·02379 „
1 Decalitre.....	=	610·23792 „
1 Hectolitre	=	3·5315 cubic feet.
1 Kilolitre	=	35·3147 „
1 Myrialitre	=	353·14694 „
The Litron usuel.....	=	62·45 cubic inches.

A TABLE

Showing the relative Value between the British Imperial Gallon and Foreign Measures of Capacity.

Places and Names of Measures.	Imp. Gall.	Places and Names of Measures.	Imp. Gall.
Amsterdam..mingle	·266	Havannah....arroba	3·415
,, ...kan	·220	Leghorn..wine fiasco	·499
Antwerp....stoopen	·608	,, ...oil fiasco	·443
,, ...litre	·220	Lisbon.....almude	3·641
Barcelona..cortane	2·270	Malta.....caffiso	4·582
Bordeaux.....velte	1·672	Mocha.....cuda	1·666
Cadiz..great arroba	3·540	Naples..wine barilla	9·164
,, ..small arroba	3·124	,, ...oil staja	2·226
Constantinople.alma	1·146	Oporto.....almude	5·311
Dantzic..beer anker	12 925	Petersburgh..wedro	2·707
,, ..wine anker	9·915	Rotterdam....stoop	·564
Genoa..wine barilla	16·349	Stockholm....kanne	·575
,, ...oil barilla	14·162	Trieste.....boccali	·312
Gibraltar....gallon	·909	Venice..wine sechii	2·377
Hamburgh..stubjen	·797	,, ...oil miro	3·356

NOTE.—The new Imperial standards of capacity, length, and weight, are not only to be adopted throughout Great Britain and Ireland, but also in all its colonies and dependencies.

IMPERIAL ALE AND BEER MEASURE.

		1 Gill..... =	8·665	cubic inches.
4 Gills..... =	1 Pint..... =	34·659	,,	
2 Pints..... =	1 Quart..... =	69·318	,,	
4 Quarts..... =	1 Gallon..... =	277·274	,,	
9 Gallons..... =	1 Firkin..... =	1·444	cubic feet.	
18 Gallons..... =	1 Kilderkin..... =	2·888	,,	
36 Gallons..... =	1 Barrel..... =	5·776	,,	
54 Gallons..... =	1 Hogshead..... =	8·665	,,	
72 Gallons..... =	1 Puncheon ..... =	11·553	,,	
108 Gallons..... =	1 Butt..... =	17·330	,,	

NOTE.—The old Ale Gallon contained 282 cubic inches, and the old Wine Gallon contained 231; hence,

Imperial Gallons	× ·98324 =	Old Ale Gallons.	
Imperial Gallons	× 1·20032 =	Old Wine Gallons.	
Old Ale Gallons	× 1·01704 =	Imperial Gallons.	
Old Wine Gallons....	× ·83311 =	,,	
Cubic feet.....	× 6·23210 =	,,	
Cubic inches.....	× ·00361 =	,,	

IMPERIAL DRY MEASURE.

		1 Gill	=	8·665 cubic inches.
4 Gills	= 1	Pint.....	=	34·659 ,,
2 Pints	= 1	Quart	=	69·318 ,,
4 Quarts.....	= 1	Gallon.....	=	277·274 ,,
2 Gallons.....	= 1	Peck.....	=	554·548 ,,
4 Pecks	= 1	Bushel	=	1·2837 cubic feet.
8 Bushels	= 1	Quarter	=	10·2700 ,,
40 Bushels.....	= 1	Wey.....	=	51·3500 ,,
80 Bushels.....	= 1	Last.....	=	102·6999 ,,

NOTE.—The Winchester bushel contained 2150·42 cubic inches, and the Imperial bushel contains 2218·192 cubic inches; hence,

Imperial bushels..... × 1·0315157 = Winchester bushels,
and Winchester bushels.. × ·9694472 = Imperial bushels.

A bushel of wheat is reckoned		= 60	*lbs.* Avoirdupois.
,,	barley	,, = 47	,,
,,	oats	,, = 38	,,
,,	pease	,, = 64	,,
,,	beans	,, = 63	,,

HEAPED IMPERIAL MEASURE OF CAPACITY FOR COALS, CULM, LIME, FISH, POTATOES, FRUIT, AND OTHER GOODS.

		The Gallon.	=	351·936 cubic inches.
2 Gallons	= 1	Peck.....	=	703·871 ,,
4 Pecks	= 1	Bushel	=	2815·487 ,,
3 Bushels	= 1	Sack.....	=	4·888 cubic feet, *nearly*
12 Sacks.....	= 1	Chaldron ..	=	58·656 ,,

DIMENSIONS OF DRAWING PAPER IN FEET AND INCHES.

Wove Antiquarian ..	4	feet	4	inches	by 2	feet	7	inches.
†Double Elephant....	3	,,	4	,,	by 2	,,	2	,,
Atlas	2	,,	9	,,	by 2	,,	2	,,
Columbier	2	,,	9¾	,,	by 1	,,	11	,,
Elephant.....	2	,,	3¾	,,	by 1	,,	10¼	,,
†Imperial	2	,,	5	,,	by 1	,,	9¼	,,
Super royal	2	,,	3	,,	by 1	,,	7	,,
Royal.....	2	,,	0	,,	by 1	,,	7	,,
Medium.....	1	,,	10	,,	by 1	,,	6	,,
Demy	1	,,	7½	,,	by 1	,,	3½	,,

DIMENSIONS OF IMPERIAL CONICAL LIQUID MEASURES.

	Diameters.				
Two Gallon ..	Top $2\frac{1}{2}$ in.	..	Bottom $11\frac{1}{2}$ in.	.. Depth	12·66498 in.
Gallon	,, 2		,, 9	,,	10·28258
Half Gallon ..	,, $1\frac{3}{4}$		,, 7	,,	8·23406
Quart	,, $1\frac{1}{4}$		,, $5\frac{3}{4}$	,,	6·33249
Pint.....	,, 1		,, $4\frac{1}{2}$	,,	5·14129
Half Pint....	,, $\frac{7}{8}$		,, $3\frac{1}{2}$	,,	4·11703
Gill.....	,, $\frac{5}{8}$		,, $2\frac{7}{8}$	,,	3·16625

DIMENSIONS OF IMPERIAL CYLINDRICAL DRY MEASURES.

Diameters and Depths.

Eighth of a Peck.....	a cylinder of	4·45232 inches.
Forpit or Half Gallon..	,,	5·60957 ,,
Gallon or Half Peck ..	,,	7·06762 ,,
Peck.....	,,	8·90464 ,,
Half Bushel.....	,,	11·21914 ,,
Bushel.....	,,	14·13524 ,,
Quarter.....	,,	28·27048 ,,

NOTE.—Multiply the decimal part by 8, the product will equal eighths of an inch, and decimal parts of an eighth of an inch.

DECIMAL FRACTIONS.

A Decimal Fraction derives its name from the Latin *decem*, "ten," which denotes the nature of its numbers, representing the parts of an integral quantity, divided into a tenfold proportion.

NUMERATION

Teacheth to read or write any number proposed, either by words or characters.

In Decimal Fractions, the integer, or whole thing, as a gallon, a pound, a yard, &c., is supposed to be divided into ten equal parts, called tenths; those tenths into ten equal parts, called hundredths; and those hun-

dredths into ten equal parts, called thousandths; and so on, without end. So that a denominator of a decimal being always known to consist of a unit, with as many ciphers as the numerator has places, is, therefore, never expressed, being understood to be 10, 100, 1000, 10000, &c., according as the numerator consists of 1, 2, 3, 4, or more figures; thus, instead of $\frac{2}{10}$, $\frac{24}{100}$, $\frac{211}{1000}$, the numerators only are written with a dot or comma before them, thus, ·2, ·24, ·211.

If a unit or whole quantity of any description, as a gallon, a pound, a foot, &c., be divided into ten equal parts, the decimal represents as many of those parts as the decimal figure expresses,—thus, ·7 means seven of those parts, or seven-tenths; but if the decimal consisted of two figures, unity would be understood to be divided into a hundred equal parts, of which the decimal represents as many as the figure expresses,—thus, ·65 means sixty-five of those parts, or sixty-five hundredths; and if the decimal consisted of three figures, unity would be supposed to be divided into a thousand equal parts, of which the decimal represents as many as the number expresses,—thus, ·625 is six hundred and twenty-five of those parts; or, suppose the decimal ·0625, unity would be understood to be divided into 10000 equal parts; but the value of decimal figures is made more plain by means of the following

TABLE.

Tenths	·5
Hundredths	·56
Thousandths.....	·567
Ten thousandths	·5678
Hundred thousandths	·56789

Thus, ·5 is read five-tenths; ·56 is read five-tenths and six hundredths, or fifty-six hundredths; ·567 is read five-tenths, six hundredths, and seven thousandths, or five hundred and sixty-seven thousandths; and so on, as in the table.

Ciphers to the right hand of decimals cause no difference in their value; for ·5, ·50, ·500 are decimals of the same value, being each equal to $\frac{1}{2}$; that is, ·5 = $\frac{5}{10}$, ·50 = $\frac{50}{100}$, ·500 = $\frac{500}{1000}$. But if ciphers are placed on the left hand of decimals, they diminish their value in a tenfold proportion; thus, ·3, ·03, ·003, are three-tenths, three-hundredths, and three-thousandths, and answer to the vulgar fractions $\frac{3}{10}$, $\frac{3}{100}$, $\frac{3}{1000}$, respectively.

A whole number and decimal are thus expressed, 85·75, 85·04, &c.

REDUCTION OF DECIMALS.

By reduction we change vulgar fractions, and the lesser parts of coin, weight, measure, &c., into decimals, and find the value of any decimal given.

Because decimals increase their value towards the left hand, and decrease their value towards the right hand, in the same tenfold proportion with integers, or whole numbers, they may be annexed to whole numbers, and worked in all respects as whole numbers; hence, if simple arithmetic be well understood, there is little more to be learned than the placing of the separating point—the rule for which ought to be well attended to.

1. *To reduce a vulgar fraction to a decimal of an equal value.*

Rule.—Add a cipher, or ciphers, to the numerator, and divide by the denominator, the quotient will be the decimal required.

EXAMPLE.—Reduce $\frac{14}{32}$ to a decimal.

32)14·0000(·4375
128
120
96
240
224
160
160

Thus you may take any number of ciphers at pleasure, but their number will be best ascertained when the work is finished; then you must have as many decimal figures as you have taken annexed ciphers in dividing; and if there are not so many in the quotient, you must prefix ciphers to the left hand of it,—thus, $\frac{1\cdot000000}{32} = \cdot03125$.

Sometimes the quotient figures will repeat continually, as $\frac{2}{3}$, thus, $\frac{2\cdot0}{3} = \cdot6'$, then it is called a repetend, and the first figure which repeats may be dashed, to distinguish it from a terminate decimal.

Sometimes two, three, or more figures will repeat, as $\frac{12}{33}$, thus, $\frac{12\cdot00}{33} = \frac{4\cdot00}{11} = \cdot3'6'$; such are called compound repetends or circulates, and the first and last of the repeating figures may be dashed.

2. *To reduce the lesser parts of coin, weights, measures, &c., to decimals.*

RULE.—Divide the least name by such number as will reduce it to the next greater; to the decimal so obtained prefix the given number of the same name, then divide by such number as will reduce it to the next greater, always annexing ciphers to the dividend, as occasion may require: thus proceed till it be reduced to the decimal of the required integer. Or, reduce the given parts to a simple quantity, by reducing them to the lowest name mentioned; annex ciphers thereto, and divide by such numbers as will reduce them to the name required. Or, reduce the given parts to a vulgar fraction, and that fraction to a decimal.

EXAMPLE 1.—Reduce 17*s.* $10\frac{1}{2}d.$ to the decimal of a pound sterling.

Here $\frac{1{\cdot}0}{2}d. = {\cdot}5d.$; and $\frac{10+{\cdot}5}{12}s. = \frac{10{\cdot}500}{12}s. = {\cdot}875s.$; then $\frac{17+{\cdot}875}{20}l. = \frac{17{\cdot}8750}{20}l. = {\cdot}89375l.$ is the decimal required.

EXAMPLE 2.—Reduce 2 *feet* 9 *inches* to the decimal of a yard.

Here $2ft.\ 9in. = 33$ inches; and $36in. = 1$ yard; hence, by vulgar fractions, $\frac{3}{3}\frac{3}{6} = \frac{33{\cdot}0000}{36} = \frac{11{\cdot}0000}{12} = {\cdot}916'6\,yd.$ as required.

To find the value of any given decimal.

RULE.—Multiply the decimal given by the number of parts of the next inferior denomination, cutting off the decimals from the product; then multiply the remainder by the next inferior denomination; thus proceeding till you have brought the least known parts of the integer.

EXAMPLE 1.—Required the value of ·89375 of a pound sterling.

$$\begin{array}{r} {\cdot}89375l. \\ 20 \\ \hline 17{\cdot}87500\ \textit{shillings.} \\ 12 \\ \hline 10{\cdot}500\ \textit{pence.} \\ 4 \\ \hline 2{\cdot}0\ \textit{farthings.} \end{array}$$

Ans. 17*s.* $10\frac{1}{2}d.$

EXAMPLE 2.—Reduce ·625 of a hundred weight to its proper terms.

Here ·625 × 4 *qrs.* = 2·500 *qrs.*, and ·5 × 28 *lbs.* = 14·0 *lbs.*; whence 2 *qrs.* 14 *lbs.* = *Ans.*

A TABLE OF RECIPROCALS,

FOR OBTAINING DECIMAL EQUIVALENTS.

No.	Recip.	No.	Recip.	No.	Recip.	No.	Recip.	No.	Recip.
1	1·000000	51	·019608	101	·009901	151	·006623	201	·004975
2	·500000	52	·019231	102	·009804	152	·006579	202	·004950
3	·333333	53	·018868	103	·009709	153	·006536	203	·004926
4	·250000	54	·018519	104	·009615	154	·006494	204	·004902
5	·200000	55	·018182	105	·009524	155	·006452	205	·004878
6	·166667	56	·017857	106	·009434	156	·006410	206	·004854
7	·142857	57	·017544	107	·009346	157	·006369	207	·004831
8	·125000	58	·017241	108	·009259	158	·006329	208	·004808
9	·111111	59	·016949	109	·009174	159	·006289	209	·004785
10	·100000	60	·016667	110	·009091	160	·006250	210	·004762
11	·090910	61	·016393	111	·009009	161	·006211	211	·004739
12	·083333	62	·016129	112	·008929	162	·006173	212	·004717
13	·076923	63	·015873	113	·008850	163	·006135	213	·004695
14	·071429	64	·015625	114	·008772	164	·006098	214	·004673
15	·066667	65	·015385	115	·008696	165	·006061	215	·004651
16	·062500	66	·015152	116	·008621	166	·006024	216	·004630
17	·058824	67	·014925	117	·008547	167	·005988	217	·004608
18	·055556	68	·014706	118	·008475	168	·005952	218	·004587
19	·052632	69	·014493	119	·008403	169	·005917	219	·004566
20	·050000	70	·014286	120	·008333	170	·005882	220	·004545
21	·047619	71	·014085	121	·008264	171	·005848	221	·004525
22	·045455	72	·013889	122	·008197	172	·005814	222	·004505
23	·043478	73	·013699	123	·008130	173	·005780	223	·004484
24	·041667	74	·013514	124	·008065	174	·005747	224	·004464
25	·040000	75	·013333	125	·008000	175	·005714	225	·004444
26	·038462	76	·013158	126	·007937	176	·005682	226	·004425
27	·037037	77	·012987	127	·007874	177	·005650	227	·004405
28	·035714	78	·012821	128	·007813	178	·005618	228	·004386
29	·034483	79	·012658	129	·007752	179	·005587	229	·004367
30	·033333	80	·012500	130	·007692	180	·005556	230	·004348
31	·032258	81	·012346	131	·007634	181	·005525	231	·004329
32	·031250	82	·012195	132	·007576	182	·005495	232	·004310
33	·030303	83	·012048	133	·007519	183	·005464	233	·004292
34	·029412	84	·011905	134	·007463	184	·005435	234	·004274
35	·028571	85	·011765	135	·007407	185	·005405	235	·004255
36	·027778	86	·011628	136	·007353	186	·005376	236	·004237
37	·027027	87	·011494	137	·007299	187	·005348	237	·004219
38	·026316	88	·011364	138	·007246	188	·005319	238	·004202
39	·025641	89	·011236	139	·007194	189	·005291	239	·004184
40	·025000	90	·011111	140	·007143	190	·005263	240	·004167
41	·024390	91	·010989	141	·007092	191	·005236	241	·004149
42	·023810	92	·010870	142	·007042	192	·005208	242	·004132
43	·023256	93	·010753	143	·006993	193	·005181	243	·004115
44	·022727	94	·010638	144	·006944	194	·005155	244	·004098
45	·022222	95	·010526	145	·006897	195	·005128	245	·004082
46	·021739	96	·010417	146	·006849	196	·005102	246	·004065
47	·021277	97	·010309	147	·006803	197	·005076	247	·004049
48	·020833	98	·010204	148	·006757	198	·005051	248	·004032
49	·020408	99	·010101	149	·006711	199	·005025	249	·004016
50	·020000	100	·010000	150	·006667	200	·005000	250	·004000

The numbers in the table are the denominators of the fraction: hence, multiply the reciprocal of the denominator by the numerator of the fraction, and the product is the decimal equivalent.

Thus, suppose the decimal equivalent of 7–16*ths* be required:—
Reciprocal of 16 = ·0625 × 7 = ·4375 its decimal equivalent.

ADDITION OF DECIMALS.

RULE.—Arrange the numbers under each other, according to their several values; find the sum, as in addition of whole numbers, and cut off for decimals as many figures to the right hand as there are decimals in any one of the given numbers.

EXAMPLE.—What is the sum of 23·45, 7·849, 543·2, 8·6234, 253·004?

23·45
7·849
543·2
8·6234
253·004
836·1264

If any of the decimals be repetends, bring all to the form of repetends, and make them begin and end together; then, in adding, increase the sum of the first column by as many units as would arise to carry to it if they were continued farther; and you will have a circulate in the sum beginning and ending like the others. Thus,

·7500′
·6666′
·8888′
·8750′
·4444′

3·6249′ = 3·625.

2·50′00000′
3·66′66666′
7·69′69696′
14·37′23723′
28·23′60087′

The repetend of ·6′, the circulate of 6′9′ and ·3′72′, are continued till their periods begin and end together. It may easily be observed that there would be two to carry to the first column if it were carried any farther.

NOTE.—It is not always necessary to attend to the rule for repetends and circulates; three or four decimal figures, according to the rule, being sufficiently near the truth for common calculations.

SUBTRACTION OF DECIMALS.

RULE.—Place the numbers directly under each other according to their several values, subtract as in whole numbers, and cut off for decimals, as in addition.

EXAMPLE.—Subtract 35·87043 from 132·005.

132·005
35·87043
96·13457

If both be single repetends, make them end together; and if there be occasion to borrow at the first figure, borrow 9 only instead of 10;

Thus, ·83′
·66′
·16′

If both be circulates, or one a repetend and the other a circulate, continue both till their periods begin and end together; then if there should be occasion to borrow at the following figure, where they continued that figure farther, carry one to the first figure; and if the numbers be in different denominations, reduce them till they be alike.

Subtract $\frac{834}{999}$ from $1\frac{2}{3}$; thus, $1\frac{2}{3} = 1{\cdot}6'66'$ and $\frac{834}{999} = {\cdot}8'34'$

${\cdot}8'31'$

MULTIPLICATION OF DECIMALS.

RULE.—Place the factors under each other, and multiply them together, as in whole numbers; then point off as many figures from the product (*counting from right to left*) as there are decimal places in both factors; observing, if there be not enough, to annex as many ciphers to the left hand of the product as will supply the deficiency.

EXAMPLE.—Multiply ·4375 by ·125.

·4375
·125
21875
8750
4375
·0546875

Here the product of ·4375 by ·125 is ·0546875; and as there are three places of decimals in the multiplier, and four in the multiplicand, a cipher must be added on the left hand of the product to reduce it to its proper terms.

To multiply a repetend by a single figure, add 1 to the first product for every 9 therein, so will you have a repetend in the product; and if there be several figures in the multiplier, do so with each product, and make them begin and end together; then add them as so many repetends.

If the multiplicand be a circulate, consider the increase that would arise to the first product if the multiplicand were continued farther: thus do with each product, make them begin and end together, and add them by the rule for adding circulates.

To contract the operation so as to retain only as many decimals in the product as may be thought necessary.

RULE.—Place the unit figure of the multiplier under that figure of the multiplicand whose place is the last to be retained in the product, and dispose of the rest so that they may all stand in contrary order to that in which they are usually placed.

Then, in multiplying, reject all the figures to the right hand of the multiplying digit, and set down the product so that the right-hand figures may fall in a straight line under each other; observing to increase the first figure of every line with what would arise by carrying 1 from 5 to 14,—2 from 15 to 24,—3 from 25 to 34, &c., from the product of the two preceding figures when you begin to multiply; and the sum will be the product required.

EXAMPLE.—Multiply 27·14986 by 92·41035, retaining four decimals in the product.

Common way.		*Contracted way.*
27·14986		27·14986
92·41035		53014·29
13	574930	24434874
81	44958	542997
2714	986	108599
108599	44	2715
542997	2	81
24434874		14
2508·9280	650510	2508·9280

DIVISION OF DECIMALS.

RULE.—Prepare your decimals as directed for multiplication, divide as in whole numbers, cut off as many figures for decimals in the quotient as the number in the dividend exceeds the number in the divisor, namely, make the number of decimal figures in the divisor and quotient together equal to the number in the dividend.

EXAMPLE.—Divide 173·5425 by 3·75.

```
3·75)173·5425(46·278
     1500
     ----
      2354
      2250
      ----
       1042
        750
        ---
        2925
        2625
        ----
         3000
         3000
         ====
```

Although you may take additional ciphers at pleasure, care must be had in reckoning the number taken in dividing for decimals in the dividend; and if you put the decimal point in the quotient at any part of the operation, continuing the operation afterwards will not cause the point to be removed.

If there should not be so many figures in the quotient as there should be decimals, prefix ciphers on the left hand to make up the number.

EXAMPLE.—Divide 1·4850 by 247·5.

Thus, $\frac{1\cdot4850}{247\cdot5} = \cdot006$. And if there be not as many decimal figures in the dividend as in the divisor, you may annex a sufficient number of ciphers; and if there be not a remainder, you must add ciphers to the right hand of the quotient till you have taken as many in the dividend as will make the decimal figures therein equal to those in the divisor: thus,—

$$\frac{14856}{2\cdot476} = 6000\cdot$$

A TABLE

Of the Fractional Parts of an Inch when divided into thirty-two parts; likewise a Foot of twelve inches reduced to Decimals.

Parts.	*Decimals.*	*Parts.*	*Decimals.*	*Parts of a Foot.*	*Decimals.*
$\frac{7}{8} + \frac{3}{32}$	= ·96875	$\frac{3}{8} + \frac{3}{32}$	= ·46875	11	= ·9166′
$\frac{7}{8} + \frac{1}{16}$	= ·9375	$\frac{3}{8} + \frac{1}{16}$	= ·4375	10	= ·8333′
$\frac{7}{8} + \frac{1}{32}$	= ·90625	$\frac{3}{8} + \frac{1}{32}$	= ·40625	9	= ·75
$\frac{7}{8}$	= ·875	$\frac{3}{8}$	= ·375	8	= ·6666′
$\frac{3}{4} + \frac{3}{32}$	= ·84375	$\frac{1}{4} + \frac{3}{32}$	= ·34375	7	= ·5833′
$\frac{3}{4} + \frac{1}{16}$	= ·8125	$\frac{1}{4} + \frac{1}{16}$	= ·3125	6	= ·5
$\frac{3}{4} + \frac{1}{32}$	= ·78125	$\frac{1}{4} + \frac{1}{32}$	= ·28125	5	= ·4166′
$\frac{3}{4}$	= ·75	$\frac{1}{4}$	= ·25	4	= ·3333′
$\frac{5}{8} + \frac{3}{32}$	= ·71875	$\frac{1}{8} + \frac{3}{32}$	= ·21875	3	= ·25
$\frac{5}{8} + \frac{1}{16}$	= ·6875	$\frac{1}{8} + \frac{1}{16}$	= ·1875	2	= ·1666′
$\frac{5}{8} + \frac{1}{32}$	= ·65625	$\frac{1}{8} + \frac{1}{32}$	= ·15625	1	= ·0833′
$\frac{5}{8}$	= ·625	$\frac{1}{8}$	= ·125	$\frac{7}{8}$	= ·072916′
$\frac{1}{2} + \frac{3}{32}$	= ·59375	$\frac{3}{32}$	= ·09375	$\frac{3}{4}$	= ·0625
$\frac{1}{2} + \frac{1}{16}$	= ·5625	$\frac{1}{16}$	= ·0625	$\frac{5}{8}$	= ·052083′
$\frac{1}{2} + \frac{1}{32}$	= ·53125	$\frac{1}{32}$	= ·03125	$\frac{1}{2}$	= ·04166′
$\frac{1}{2}$	= ·5			$\frac{3}{8}$	= ·03125
				$\frac{1}{4}$	= ·02083′
				$\frac{1}{8}$	= ·010416′

The utility of this table will appear evident by means of the following example:—

Suppose a board or plate to be $30\frac{1}{4}$ inches long, $8\frac{5}{8}$ inches broad, and $\frac{3}{8} + \frac{1}{16}$ of an inch in thickness; required its contents in cubic inches.

Here 30·25 × 8·625 = 260·90625, and 260·90625 × ·4375 = 114·14648, &c., the number of cubic inches. = *Ans.*

OF THE SQUARE ROOT.

When a number is multiplied by itself, as 6×6, or 9×9, &c., it produces the square or second power of that number; and the number itself is called the root of that square.

A root consisting of a single figure is found by inspection of the following table :—

Root	1	2	3	4	5	6	7	8	9
Squares	1	4	9	16	25	36	49	64	81
Cubes	1	8	27	64	125	216	343	512	729

To extract or find the square root of any number which consists of more figures than one.

Rule.—Make a point or dot over every second figure, commencing at the right hand, by which the given square will be pointed into periods of two figures each, except the first or left-hand period, which will sometimes have but one.

The unit figure must always be the latter figure in the period; for the decimal point must be between the periods, and not in the middle of a period.

Find the greatest root in the first period, which write in the quotient or root, and the square thereof under the same period; subtract therefrom, and to the remainder annex the next period for a dividend.

Double the quotient for a divisor; see how often the divisor is contained in the dividend, with this consideration, that the answer must be the unit's figure of the divisor.

Write the answer in the quotient, also in the unit place of the divisor; then multiply the divisor so completed by the last quotient figure; write the product under the dividend, and subtract therefrom; to the remainder annex the next period for a new dividend.

Thus proceed with every period; and if there be still a remainder, annex pairs of ciphers for additional periods, till you have a competent number of decimals in the root.

Vulgar fractions, &c., may be reduced to decimals.

The periods which are whole numbers give whole numbers, and decimal periods give decimals in the root.

EXAMPLE 1.—What is the square root of 76176?

```
 76176(276
 4
 ---
47)361
   329          The proof = 276 × 276 = 76176.
 ---
546)3276
   3276
 ====
```

EXAMPLE 2.—Required the square root of ·75.

```
 ·75(·866
 64
 ---
166)1100
    966   The proof = ·866² + ·000044 = ·75.
 ---
1726)10400
    10356
 ---
     44 remainder.
 ====
```

EXAMPLE 3.—Required the square root of ·000854.

```
 ·000854(·029 and ·029
    4              ·029
 ---            ---
 49)454          261
    441           58
 ---            ---
Remainder 13    ·000841
 ====           +  13
               ---
               ·000854 = Proof.
               ====
```

OF THE CUBE ROOT.

When a square is multiplied again by its root, as $6 \times 6 \times 6$, it produces the cube or third power of that root.

Single cubes are found by inspection of the preceding table.

To extract the root of any number that consists of more than one figure.

RULE.—Point the given cube into periods of three figures, and so that the unit figure be the last in its period; then from the first period subtract the greatest cube it contains; put the root as a quotient, and to the remainder bring down the next period for a dividend.

Find a divisor by multiplying the square of the root by 300; see how often it is contained in the dividend; and the answer gives the next figure in the root.

Multiply the divisor by the last figure in the root. Multiply all the figures in the root by 30, except the last; and that product by the square of the last. Cube the last figure in the root; add these three last-found numbers together, and subtract this sum from the dividend; to the remainder bring down the next period for a new dividend, and proceed as before.

EXAMPLE.—Required the cube root of 444194947.

```
                                444194947(763
                                343
                               ------
  7 x  7 x 300 = 14700)101194
                               95976
                               ------
 76 x 76 x 300 = 1732800)5218947
                               5218947
                               =======
```

1. Divisor 14700		2. Divisor 1732800	
	6		3
	88200		5198400
$7 \times 30 \times 36 =$	7560	$76 \times 30 \times 9 =$	20520
$6 \times 6 \times 6 =$	216	$3 \times 3 \times 3 =$	27
	95976		5218947

Besides the preceding, there is another, and, perhaps, a better way of extracting the cube root, and which we shall attempt to render as intelligible as possible, by an explanation of the following example:—

EXAMPLE.—Required the cube root of 926859375.

1st Cipher.	*2nd Cipher.*	
0	0	926859375(975
9	81	729
9	81	197859
9	162	183673
18	24300	14186375
9	1939	14186375
270	26239	
7	1988	
277	2822700	
7	14575	
284	2837275	
7		
2910		
5		
2915		

After having divided the number into periods of three figures each as before, place before it two ciphers, at moderate distances from each other, and from the number itself, as represented in the example; then find, by a reference to the table, *page* 20, the nearest cube contained in 926, the first period, and place its root, which is 9, in the quotient, as the first figure of the required root. Place it also under the first cipher, and by going through the process of addition, we obtain 9. Multiply this by 9, and place the product under the second cipher. By again going through the form of addition we get 81, which being multiplied by 9, becomes 729. This is placed under the first period of figures 926, and subtracted from it, and to the remainder the second period 859 is annexed. Then recommencing at the column of the first cipher, we again place a 9, and add up. To the sum we add another 9, and obtain 27. We now multiply the 18 by 9, and place the product 162 under the 81 of the second column, and by addition we obtain 243. We now turn

to the first column, and annex one cipher to the 27, making it 270; and in a similar manner annex two ciphers to the 243 of the second column. All this is done preparatory to finding the second figure of the quotient, or of the required root.

To find that figure we divide the number 197859 of the third column by 24300 of the second column. The quotient would appear to be 8: this, however, is found on trial to be too large, and we therefore take 7, which answers. We add this 7 to the first column, and multiply the sum 277 by 7, placing the product 1939 in the second column. Then, by adding up, we obtain 26239, the product of which by 7 we place in the third column and subtract, and to the remainder we annex the last period of figures 375. Recommencing at the first column, we add 7 to the 277, and to the sum 284 we add 7 again. We now multiply the sum 284 by 7, and place the product in the second column and add up. Then to the 291 in the first column we annex one cipher, and to the 28227 in the second column two ciphers.

To find the third figure of the root we divide the number 14186375 in the third column by the 2822700 in the second column, and the quotient is found to be 5. This we add to the first column, and multiply the sum 2915 by 5, and place the product under the 2822700 of the second column. Upon adding we obtain 2837275, whose product by 5 is placed under the 14186375 of the third column, and, being exactly equal to it, there is no remainder upon subtracting; consequently the work is finished, and 975 is the required cube root.

N.B.—The above method is not only useful for extracting the cube root, but also for that of any other root, attention being paid to the following directions:—

Instead of dividing the number whose root is to be extracted into periods of three figures each, we divide it into periods of as many figures each as correspond to the order of the root; as, for example, four figures for the fourth root, five for the fifth, &c.; but the number of ciphers which we employ must be one less than that which corresponds to the order of the root, as three ciphers for the fourth root, and four for the fifth root. It must be borne in mind, too, that every new figure which we place in the quotient must be added to the first column as many times as correspond to the order of the root, and that the number of products added to the second column be one less than the above number, and that added to the third two less, and so on.

Lastly, before finding a new figure for the quotient, we annex one cipher to the number in the first column, two to that in the second, three to that in the third, and so on, until we arrive at the last column, where, instead of annexing ciphers, we bring down the numbers that make up the next period.

If, after extracting the root, we have a remainder, we can continue the quotient to decimals, by annexing to the remainder as many ciphers as there are figures in a period, and then proceeding as before; and if the number whose cube root is to be extracted consist of a whole number and a decimal, we divide it into periods by commencing at the unit's place, and proceeding towards the left hand to divide the whole number, and towards the right to divide the decimal; and if the decimal do not contain a sufficient number of figures to make up the last period, we supply the deficiency with ciphers.

The following example will, perhaps, make the subject a little more plain:

EXAMPLE.—Required the fourth root of 285762·321.

1st Cipher.	*2nd Cipher.*	*3rd Cipher.*	
0	0	0	285762·3210(23·12
2	4	8	16
–	–	–	—
2	4	8	125762
2	8	24	119841
–	—	—	———
4	12	32000	..59213210
2	12	7947	48986321
–	—	———	———
6	2400	39947	102268890000
2	249	8721	98739268336
–	———	———	———
80	2649	48668000	..3529621664 *rem.*
3	258	318321	
—	———	———	
83	2907	48986321	
3	267	319243	
—	———	———	
86	317400	49305564000	
3	921	64070168	
—	———	———	
89	318321	49369634168	
3	922	———	
———	———		
920	319243		
1	923		
———	———		
921	32016600		
1	18484		
———	———		
922	32035084		
1	———		
———			
923			
1			
———			
9240			
2			
———			
9242			
———			

Involution and Evolution of numbers are very conveniently performed upon the *Engineer's Slide Rule*, for when the slide is set straight at both ends, C is a line of squares, and D a line of roots; consequently, against any number upon D is its square upon C, and against any number upon C is its root upon D.

EXAMPLE 1.—What is the square of 16?

Opposite 16 upon D is 256, the square number upon C.

EXAMPLE 2.—Required the square root of 625.

Opposite 625 upon C is 25 upon D, the root required.

The cube root is performed by inverting the slide, and setting the number to be cubed upon B to the same number upon D, and against 1 or 10 upon D is the cube number upon B. Also, set the cube number upon B to 1 or 10 upon D, and where two numbers of equal value meet upon the lines B and D is the root required.

EXAMPLE 1.—Required the cube of 9.

Set 9 upon B to 9 upon D, and against 10 upon D is 729 upon B.

EXAMPLE 2.—Required the cube root of 343.

Set 343 upon B to 10 upon D, and against 7 upon B is 7 upon D, the root required.

These lines also serve to multiply the square of any number, any number of times: thus,—

To find the product of 6 times 6, multiplied by 3.

Set 3 upon B to 6 upon D, and against 10 upon D is 108 upon B.

To find the root of a number consisting of integers and decimals.

RULE.—Multiply the difference between the root of the integral part of the given number, and the root of the next higher integer number, by the decimal part of the given number, and add the product to the root of the integral part of the number given; the sum will be the root of the number required, correct in all cases of the square root to 3 places, and in the cube root to 7, if the roots of the integral parts are correct to 4 places of decimals.

EXAMPLE 1.—Required the square root of 60·2.

$\sqrt{61} = 7{\cdot}8102$

$\sqrt{60} = 7{\cdot}7460$

difference $\cdot 0642$

$\times \quad \cdot 2$

Product $= \quad \cdot 01284$

Then $+ \quad 7{\cdot}7459$

$\therefore \sqrt{60{\cdot}2} = 7{\cdot}75874$ as required, correct to 3 places of decimals.

EXAMPLE 2.—Required the cube root of 843·75.

$\sqrt[3]{844} = 9{\cdot}4503$

$\sqrt[3]{843} = 9{\cdot}4466$

difference $\cdot 0037$

$\times \quad \cdot 75$

Product $= \quad \cdot 002775$

Then $+ \quad 9{\cdot}4466$

$\therefore \sqrt[3]{843{\cdot}75} = 9{\cdot}449375$ as required.

If the square root is required, correct to more places of decimals, the following rule is correct to 7 places:—

Multiply the root of the nearest integer number by twice the difference between that and the given number, and divide the product by 3 times the integer number added to the given number; and the quotient added to the root of the integer number will be the root of the given number nearly. Then, the root of 60·2 will stand thus,

$\sqrt{60} = 7{\cdot}7460$

$\times \quad \cdot 4 = \cdot 2 \times 2$

$(60 \times 3) + 60{\cdot}2 = 240{\cdot}2)3{\cdot}09840(\cdot 01289 + 7{\cdot}7460 = 7{\cdot}75889$ the root required.

2 402

6964

4804

21600

19216

23840

If the number consist wholly of decimals, the root will be decimals also.

PRACTICAL GEOMETRY.

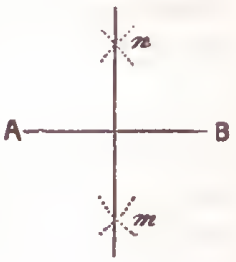
Geometry is the science which treats of that species of quantity called magnitude, as represented by lines, surfaces, and solids.

Practical Geometry is that art by which we are enabled to turn the rules of the science to a practical account.

PROBLEM I.

To divide a given line into two equal parts.

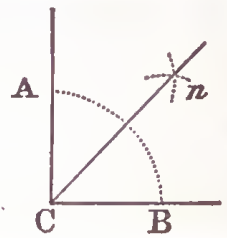
From A and B as centres, with any distance greater than half the length of the line, describe arcs cutting each other in *m* and *n*; then a line drawn through the points *m* and *n* will divide the line into two equal parts, as required.



PROBLEM II.

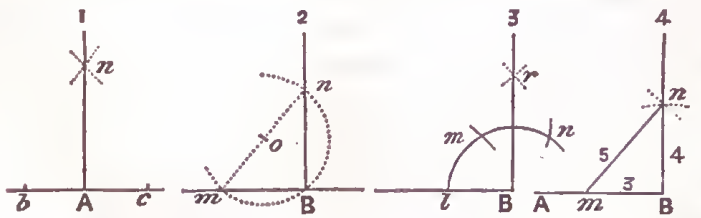
To divide a given angle into two equal parts.

From the point C as a centre with any distance at pleasure, describe the arc A B; and from A and B as centres, with the same or any other convenient distance, describe arcs cutting each other in *n*; then a line drawn from the point C, through *n*, will divide the angle as required.



PROBLEM III.

From any given point in a right line to erect a perpendicular.



1.—On each side of the point A, take equal distances,

as A *b*, A *c*; from *b* and *c*, as centres, with any radius greater than *b* A or *c* A, describe arcs cutting each other in *n*; then will a line drawn from the point A through *n* be the perpendicular required.

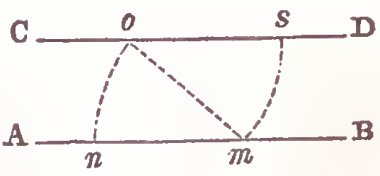
2.—Take any point *o*, and with *o* as centre, and *o* B as radius, describe the arc *m* B *n*, cutting the line in *m* and B; draw a line from *m* through the centre *o*, and continue it until it cut the opposite side of the arc in *n*; then the line which joins *n* and B is the perpendicular required.

3.—With the point B as centre, and with any radius, describe the arc *l m n*, cutting the line in *l*; with *l* as centre, and the same radius, cut the arc in *m*; and with *m* as centre, and the same radius, cut the arc again in *n*. Now, with *m* and *n* as centres, and with any radius, describe arcs cutting each other in *r*, then the line joining *r* and B is the perpendicular required.

4.—From the point B, on the line A B, take three equal parts (as feet, inches, &c.) to *m*: and from *m* and B as centres, describe arcs cutting each other in *n*, making the distance from B to *n* four parts, and from *m* to *n* five parts, then will the line B *n* be the perpendicular required.

PROBLEM IV.

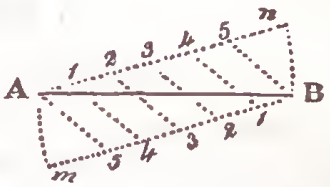
Through a given point o, to draw a straight line C D, *parallel to a given straight line* A B.



Take any point *m* in the line A B; with *m* as a centre and radius *m o*, describe the arc *o n*; with *n* as a centre and the same distance describe the arc *s m*. Take the arc *o n* in your compasses, and apply it from *m* to *s*; through *o s* draw C D, and it will be the parallel as required.

PROBLEM V.

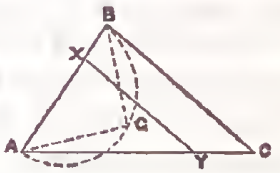
To divide a right line into any number of equal parts.



Let A B be the line that is to be divided; then at the point A draw a line making any angle with the line A B and at B draw another line parallel to it. Upon each of these lines, beginning at the points A and B, cut off as many equal parts as you require the line A B to be divided into, as A 1, 1 2, 2 3, &c., B 1, 1 2, 2 3, &c.; then draw lines joining the points A and 5, 1 and 4, 2 and 3, &c., and the lines so drawn will cut A B into the required number of equal parts.

PROBLEM VI.

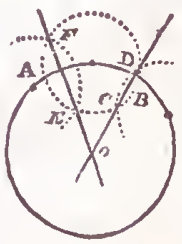
To divide a triangle into two equal parts, and still retain its original form.



Let A B C be the given triangle to be divided, bisect one of its sides as A B, and describe the semicircle A G B; bisect the semicircle in G, and at a distance from A, equal to A G or B G, draw the line *x y*, parallel to B C, which is the line of equal division as required.

PROBLEM VII.

Through any three points out of a right line to describe the circumference of a circle.



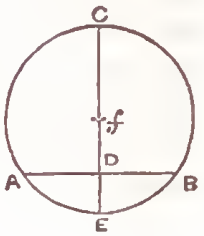
From the middle point as a centre, with any convenient distance, describe the circle, or arcs of a circle, as A and B, and from the other points, with the same distance, describe arcs cutting the circle in C D and E F; draw lines through C D and E F, and where

they intersect each other at *o* is the centre of the circle required.

PROBLEM VIII.

To find the centre of a given circle.

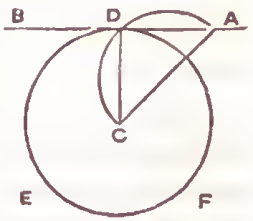
Draw any chord A B, bisect it in D, and through D draw E C perpendicular to A B; then bisect E C, and the point of section *f* will be the centre of the circle.



PROBLEM IX.

From a given point to draw a tangent to a circle.

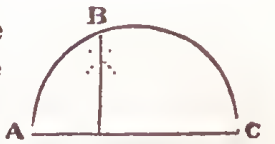
Let A be the point from which it is required to draw a tangent to the circle D E F. Join A and the centre C, and upon the line A C describe the semicircle A D C, then through D, the point at which the circles intersect, draw the line A B, which will be the tangent required.



PROBLEM X.

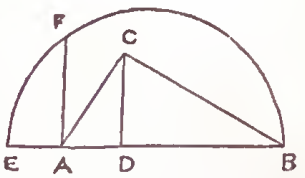
To find a mean proportional between two given right lines, or the side of a square equal to a given rectangle.

Upon a right line as a diameter equal to both given lines, describe the semicircle A B C, and where the two lines meet, or between their respective lengths, erect a perpendicular to the semicircle at B, and the perpendicular will be the mean proportion or side of the required square, equal to the given rectangle.



PROBLEM XI.

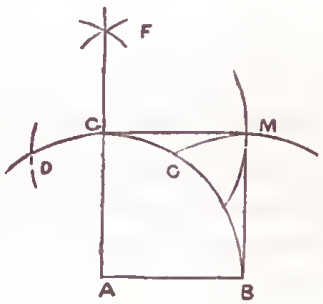
To find the side of a square which shall be equal in area to a given triangle.



Let A B C be the given triangle. From C let fall C D perpendicular to A B, and produce the line B A to E, making A E equal to half the perpendicular C D; then upon E B describe the semicircle E F B, and from the point A erect a perpendicular cutting the circle in F; then A F will be the side required.

PROBLEM XII.

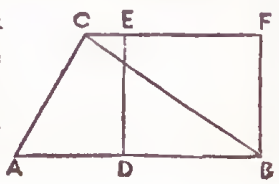
Upon a given right line to construct a square.



Let A B be the line upon which it is required to construct a square. With A as centre, and A B as radius, describe the arc B C D; with B as centre, and the same radius, cut the arc in C; and with C as centre, and the same radius, cut the arc again in D; then with C and D as centres, and with equal radii, describe arcs cutting each other in F, and from F draw F A, cutting the circle in G. Then with G and B as centres, and the distance A B as radius, describe arcs cutting each other in M; join G M and B M, and the figure G M B A is the required square.

PROBLEM XIII.

To make a rectangle equal to a given triangle.

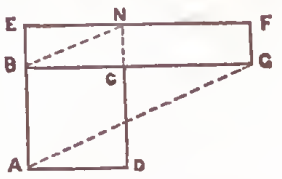


Let A B C be a triangle, to which it is required to make a rectangle equal. Bisect A B in D, and at D erect a perpendicular; from B draw a line parallel to D E, and from C

draw a line parallel to A B; then the figure D E F B is the rectangle required.

PROBLEM XIV.

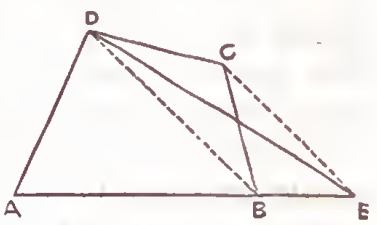
To produce a rectangle equal to a given square.



Suppose A B C D be the given square, also B E one end of the required rectangle, draw E F parallel to B C, join B N, continue the side of the square B C, and draw the line A G parallel with B N, until it intersects at G, then B G is the side of the rectangle required.

PROBLEM XV.

To make a triangle equal to a given quadrilateral figure.

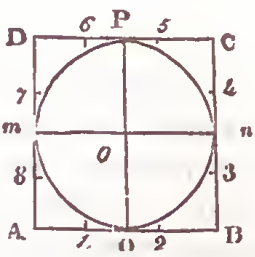


Let A B C D be the given quadrilateral figure.

Join D and B, and from C draw C E parallel to B D; produce A B to E, and join D and E; then the triangle A D E is the triangle required.

PROBLEM XVI.

To circumscribe a square about a given circle.



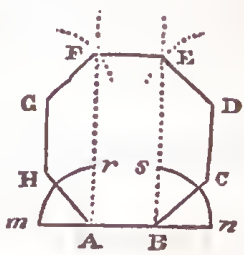
Draw two diameters at right angles as *m n* and O P; from *m n* O P as centres, with the radius of the circle, describe arcs cutting each other in A B C and D; join A B, B C, C D, D A, and A B C D will be the square required.

And from A as a centre, with the distance A *o*, cut

the lines A B, A D, in 2 and 7; from B as a centre cut the lines B A, B C, in 1 and 4; from C as a centre cut the lines C B, C D, in 3 and 6; and from D as a centre cut the lines D C, D A, in 5 and 8; join 1, 8; 2, 3; 4, 5; and 6, 7; and 1, 2, 3, 4, 5, 6, 7, 8, will be a regular octagon.

PROBLEM XVII.

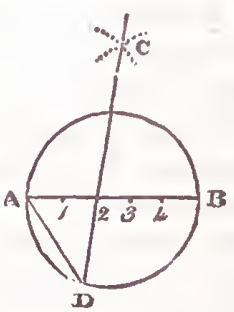
Upon a right line to describe an octagon.



On the extremities of one side A B erect the perpendiculars A F and B E; continue the line A B to A *m* and B *n*, forming the angles *m* A *r* and *n* B *s*; bisect the angles with the lines A H and B C; make each of those lines equal to A B; make H G and C D the same length, and parallel to A F and B E: from G and D as centres, with the radius A B, describe arcs cutting A F and B E; join G F, F E, and E D, then A B C D E F G H will be the octagon required.

PROBLEM XVIII.

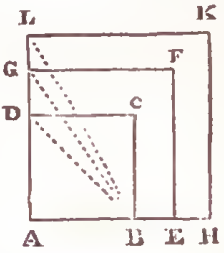
In a given circle to inscribe any regular polygon.



Divide the diameter A B into as many equal parts as the polygon is required to have sides; from A and B as centres, with the distance A B, describe arcs cutting each other in C; draw a line through the second division, meeting the circumference at D; join A D, and it will be the side of the polygon required.

PROBLEM XIX.

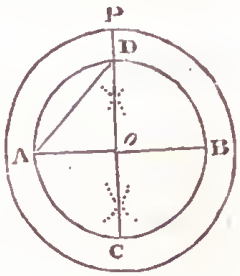
To find the side of a square that shall be any number of times the area of a given square.



Let A B C D be the given square, then will the diagonal B D be the side of a square A E F G, double in area to the given square A B C D; and if the diagonal be drawn from B to G, it will be the side of a square A H K L, three times the area of the square A B C D, or the diagonal B L will equal the side of a square four times the area of the square A B C D, &c.

PROBLEM XX.

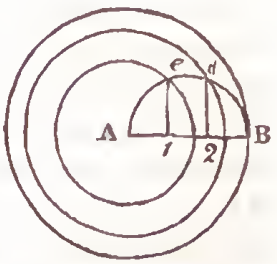
To find the diameter of a circle that shall be any number of times the area of a given circle.



Let A B C D be the given circle; draw the two diameters A B and C D at right angles to each other, and the chord A D will be the radius of the circle *o* P, twice the area of the given circle nearly; and half of this chord A D will be the radius of a circle that will contain half the area, &c.

PROBLEM XXI.

To divide a given circle into any number of co-centric parts equal to each other.

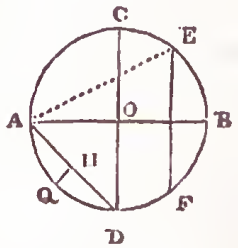


Upon the radius A B describe the semicircle A *e d* B; divide A B into the proposed number of equal parts, as 1, 2, &c.; erect the perpendiculars 1 *e*, 2 *d*, &c., meeting the semicircle in *e* and *d*; then from the centre A, and radii A *e*, A *d*, &c., describe circles; so shall the circle be divided into the proposed number of equal parts as required.

PROBLEM XXII.

To find the side of a square nearly equal in area to a given circle.

Draw the two diameters A B and C D at right angles to each other, bisect the radius O C by a line from one end of the diameter at A, meeting the circumference in E, then will the line A E be the side of a square nearly equal in area to the given circle.



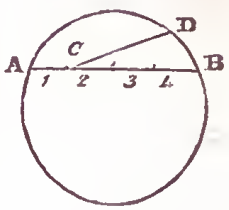
And if the line E F be drawn parallel to C D, it will be $\frac{1}{4}$ of the circumference nearly.

Or three times the diameter A B or C D, and once the versed sine Q H, of the angle A O D, will be the circumference nearly.

PROBLEM XXIII.

To find a right line that shall be nearly equal to any given arc of a circle.

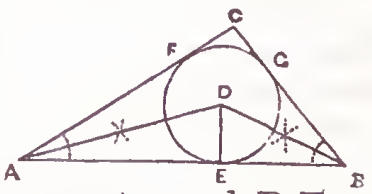
Divide the chord A B into four equal parts, set one part on the circumference from B to D, draw a line from C, the first division on the chord; and twice the length of the line C D will be the length of the arc nearly.



PROBLEM XXIV.

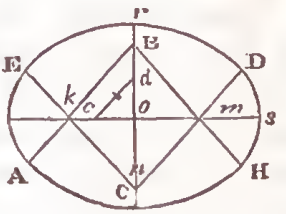
To describe the largest possible circle in a triangle.

Let A B C be a triangle; bisect the two angles A and B (by Problem II.), and from D, where the lines A D and B D meet, draw D E perpendicular to A B; then, with D as centre, and D E as radius, describe the circle E F G, which is the one required.



PROBLEM XXV.

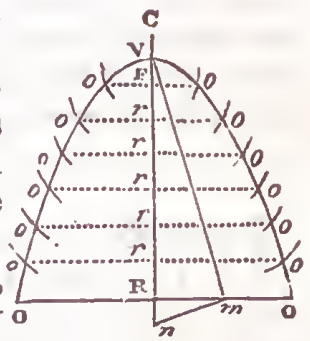
To describe an ellipsis, the transverse and conjugate diameters being given.



From *o* as a centre, with the difference of the transverse and conjugate semi-diameters, set off *o c* and *o d;* draw the diagonal *c d*, and continue the line *o c* to *k*, by the addition of half the diagonal *c d*, then will the distance *o k* be the radius of the centres that will describe the ellipsis; draw the lines A B, C D, C E, and B H, cutting the semi-diameters of the ellipsis in the centres *k* B *m n;* then with the radius *m s*, and with *k* and *m* as centres, describe the arcs D H and A E; also, with the radius *n r*, and with *n* and B as centres, describe the arcs E D and A H, and the figure A E D H will be the ellipsis required.

PROBLEM XXVI.

To describe a parabola, any ordinate to the axis and its abscissa being given.



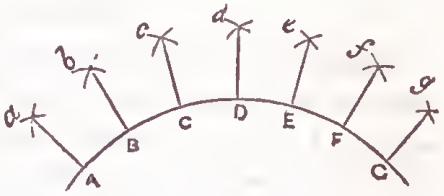
Let V R and R *o* be the given abscissa and ordinate; bisect R *o* in *m*, join V *m*, and draw *m n* perpendicular to it, meeting the axis in *n;* make V C and V F each equal to R *n*, then will F be the focus of the curve.

Take any number of points, *r*, *r*, &c., in the axis, and draw the double ordinates of an indefinite length.

From F as a centre, with the radii C F, C *r*, &c., describe arcs cutting the corresponding ordinates in the points *o o o o*, &c., and the curve *o* V *o* drawn through all the points of intersection will be the parabola required.

PROBLEM XXVII.

To draw at the circumference of a circle lines tending towards the centre when the centre is inaccessible.

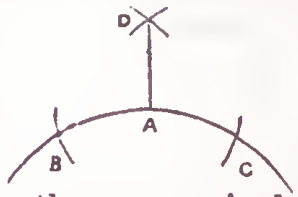


Mark off upon any portion of the circumference any number of equal parts, and with any radius greater than the length of one division, but less than that of two, and with the centres A, B, C, D, &c., describe arcs cutting each other in *b*, *c*, *d*, &c.; then the required lines may be drawn by joining *a* A, *b* B, *c* C, and so on.

To draw the end lines a A, *g* G.

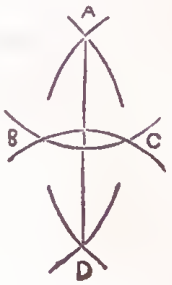
With the distance A *b* as radius, and with the centres B and F, describe the arcs *a* and *g*; then, with the distance B *b* as radius, and the centres A and G, describe arcs cutting the former ones, and at the points of intersection *a* and *g* draw A *a* and *g* G, which will be the required straight lines.

From any given point in the circumference (as A *in the annexed figure) to draw a line tending towards the centre.*



With A as centre, and with any radius, cut the circle in B and C; then with B and C as centres and a radius greater than the former, describe arcs cutting each other in D; join D and A, and the line D A will be the one required.

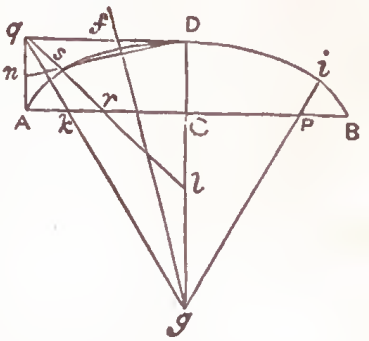
To draw from a point, without the circumference, a line tending towards the centre.



Let A be the given point. With A as centre, and with any convenient radius, describe an arc cutting the circumference in B and C; with B and C as centres, and the distance B A as radius, describe arcs cutting each other in A and D; then join A and D, and the line so drawn will be the one required.

PROBLEM XXVIII.

To describe an elliptical arc, the width and rise of span being given.



Bisect the chord or width of span A B, and at the point of section C erect a perpendicular C D equal to the height of span; erect a perpendicular also at A, making A q equal to C D; join q and D, and bisect A q in n, and A C in r; join n and D, and from q through r draw the line $q\ l$, meeting the line D C produced. Now, bisect the line s D in f, and at the point of section erect at right angles the line $f\ g$, also meeting the line D C produced, join g and q, and the line so drawn will cut the line A B in k; make C P equal to C k, and through P draw the line $g\ i$; then, with g as centre and g D as radius, describe the arc s D i, and with k and P as centres and k A and P B as radii, describe the arcs A s and B i; the construction of the arc will then be completed.

MENSURATION.

Mensuration is the method of calculating the comparative magnitudes of figures; and it is divided into two parts,—Mensuration of Superficies or Surfaces, and Mensuration of Solids.

The magnitude of a surface is called its area, and is the space enclosed between its boundary lines.

The magnitude of a body is called its solid contents, and is expressed in cubic feet, inches, &c.

MENSURATION OF SUPERFICIES.

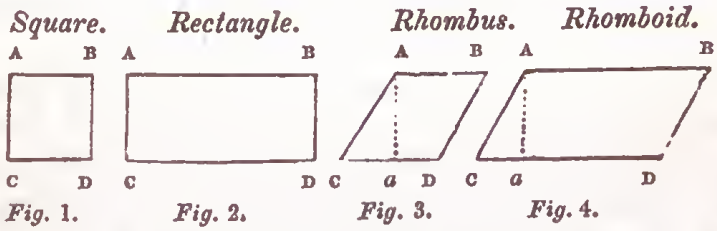


Fig. 1. *Fig.* 2. *Fig.* 3. *Fig.* 4.

A SQUARE is a quadrilateral figure which has all its sides equal, and all its angles right angles.

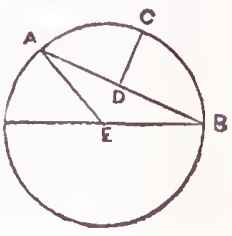
A RECTANGLE is a four-sided figure which has its angles right angles, and its opposite sides parallel.

A RHOMBUS is a parallelogram whose sides are equal, but whose angles are not right angles.

A RHOMBOID is a parallelogram whose adjacent sides are unequal, and whose angles are not right angles.

A TRAPEZOID is a four-sided figure which has but two of its sides parallel.

A CIRCLE is a figure bounded by one line called the circumference; and is such, that all lines drawn to the circumference from a certain point within the figure called the centre are equal to each other. Any of these lines is called



a radius; and a line drawn through the centre, terminating both ways in the circumference, is called a diameter. The portion of circle cut off by a diameter is called a semicircle.

An Arc of a circle is any portion of the circumference.

A Segment of a circle is a figure contained by an arc and its chord.

A Versed Sine is a line drawn from the middle of a chord perpendicular to the circumference.

A Sector of a circle is a figure contained by two radii and an arc, as A C B E.

Some useful Properties of Numbers employed in the Solutions of the following Problems.

1. Half the sum of any two numbers increased by half their difference, will give the greater number; and half their sum diminished by half their difference, will give the less number.

2. The quotient arising from the division of the sum of two or more numbers, is equal to the sum of the quotients arising from the division of the parts separately, by the same divisor.

3. Any three of the four following quantities of a division sum, *viz.* divisor, dividend, quotient, and remainder, being given, the fourth may be found by the following formula. Let $d =$ the divisor; $\text{D} =$ the dividend; $q =$ the quotient; and $r =$ the remainder. Then we shall have

$$d = \frac{\text{D} - r}{q}; \ \text{D} = (d \times q) + r; \ q = \frac{\text{D} - r}{d}; \text{ and } r = \text{D} - (q \times d).$$

4. An even number cannot divide or measure an odd number, nor a greater a less.

5. A given number is divisible by 2 if the last digit is even; it is divisible by 4 if the last two digits are divisible by 4; it is divisible by 8 if the last three digits are divisible by 8; and in general it is divisible by 2^n, if the last n digits are divisible by 2^n.

6. A number is divisible by 3 if the sum of the digits is divisible by 3; such number also may be divided by 6 if, besides this, the last digit is even; it is also divisible by 9 if the sum of the digits can be divided by 9. The method of proof, by casting out the nines, in Addition, Multiplication, and Division, depends upon this theorem.

7. Every number that has the last digit 5 or 0, such number is divisible by 5 in both cases, and by ten in the latter case.

8. A number is divisible by 11 when the sum of the digits in the odd places (counting from the right or unit's place) be equal to the sum of the digits in the even places; or if the difference of these sums be divisible by 11, the number itself is divisible by 11.

9. If any two numbers be separately divided by 9 or 3, and the two remainders multiplied together, and that product divided by 9 or 3, the last remainder will be the same as if you divided the product of the first two numbers by 9 or 3.

10. If any number ending with 1, 3, 7, or 9, be the numerator or denominator of a fraction, and will not divide by 3, 7, or 9, that fraction is *generally* in its lowest terms, for

Every number must terminate in one or other of the ten digits . . .	0 1 2 3 4 5 6 7 8 9
But no even number can be a prime number; hence, take away . .	. . 2 . 4 . 6 . 8 .
We have remaining	0 1 . 3 . 5 . 7 . 9
No number terminating in 0 or 5 can be prime	0 . . . . 5 . . . .
Hence it follows that every prime number must terminate in one or other of these four digits . . .	. 1 . 3 . . . 7 . 9

But of such numbers none the sum of whose digits is a multiple of 3 can be prime. Nor any terminating in 1, 3, 7, 9, that is, in any power or multiple of another number.

11. Every prime number is of one of the forms $8n + 1$, $8n + 3$, $8n + 5$, $8n + 7$; $12n + 1$, $12n + 5$, $12n + 7$, $12n + 11$; $4n \pm 1$; $6n \pm 1$; $16n \pm 1$, $16n \pm 3$, $16n \pm 5$, $16n \pm 7$; $60n \pm 1$, $60n \pm 7$, $60n \pm 11$, $60n \pm 13$, $60n \pm 17$, $60n \pm 19$, $60n \pm 23$, $60n \pm 29$.

12. When any prime number (above the number 3) is either increased or diminished by unity, the result is always divisible by 6; thus, take for example, $(173 + 1) \div 6 = 174 \div 6 = 29$, and $(5749 - 1) \div 6 = 5748 \div 6 = 958$.

13. When any set of numbers are placed in the form of fractions, with the sign of addition or subtraction between them, and should the whole of these numbers that are in the numerator and denominator contain a common divisor, they may be abbreviated by dividing each of them by the common divisor.

14. When the numerator is equal to the denominator, the fraction is equal to the integer; thus, $\frac{6}{6} = 1$.

15. When the numerator is greater than the denominator, the fraction is greater than the integer; as, $\frac{5}{3} = 1\frac{2}{3}$.

16. If the numerator and denominator of a fraction be either multiplied or divided by the same number, the product or quotient will be a new fraction equal in value to the former; thus, $\frac{6}{9} \div \frac{3}{3} = \frac{2}{3}$, or $\frac{6}{9} \times \frac{4}{4} = \frac{24}{36}$, all of which have the same value, for $\frac{6}{9} = \frac{2}{3} = \frac{24}{36}$.

PROBLEM I.

To find the area of any parallelogram.

RULE.—Multiply the length by the perpendicular height, and the product will be the area.

EXAMPLE.—Required the area of a rhomboid A B D C (*Fig.* 4, *page* 41) whose length A B = 20·5, and perpendicular height a A = 11·75.

Here A B × a A = 20·5 × 11·75 = 240·875, the area of the rhomboid A B D C.

NOTE.—In a square (*Fig.* 1), or rectangle (*Fig.* 2, *page* 41), the perpendicular height is the breadth; therefore, to find the areas of a square and rectangle, multiply the length by the breadth.

PROBLEM II.

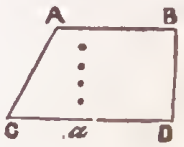
To find the area of a trapezoid.

RULE.—Add together the two parallel sides, multiply their sum by the breadth or height, and half the product is the area.

EXAMPLE.—Required the area of a trapezoid whose sides A B and C D are 14·5 and 10·25, and breadth a A = 7·25.

Here $\frac{(A B + C D) \times a A}{2} =$

$\frac{(14{\cdot}5 + 10{\cdot}25) \times 7{\cdot}25}{2} = 89{\cdot}71875,$



the area of the trapezoid A B D C.

PROBLEM III.

To find the area of a triangle.

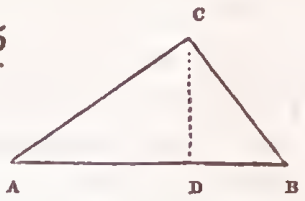
RULE.—Multiply one of its sides as a base by a perpendicular let fall from the opposite angle, and take half the product for the area.

Or, from half the sum of the three sides subtract each side separately, and multiply the three remainders so obtained and the half sum together, and the square root of the product will be the area.

EXAMPLE 1.—Required the area of a triangle A B C, whose base A B = 16·5, and perpendicular D C = 10·25.

Here $\frac{A B \times D C}{2} = \frac{16{\cdot}5 \times 10{\cdot}25}{2}$

= 84·5625, the area of the triangle A B C.



EXAMPLE 2.—What is the area of the triangle A B C, whose sides are B C = 8, A C = 12, and A B = 16 respectively?

Here $\frac{1}{2}$ (A B + A C + B C) = $\frac{1}{2}$ (16 + 12 + 8) = 18 = half the sum of the three sides.

$$\left.\begin{array}{l} 18 - 16 = 2 \\ 18 - 12 = 6 \\ 18 - 8 = 10 \end{array}\right\} \text{the three remainders.}$$

Then $\sqrt{}$ (18 × 2 × 6 × 10) = $\sqrt{}$ 2160 = $\sqrt{}$ (3^2 × 4^2 × 15) = 12 $\sqrt{}$ 15 = 12 × 3·873 = 46·476 = the area of the triangle A B C = *Ans.*

PROBLEM IV.

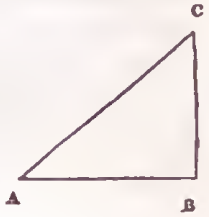
If any two sides of a right-angled triangle be given, the third side may be found by the following rules.

1. To the square of the base add the square of the perpendicular; and the square root of the sum will be the hypotenuse or longest side.

2. Multiply the sum of the hypotenuse, and one side by their difference; and the square root of the product will be the other side.

EXAMPLE 1.—Given the base A B = 16, and perpendicular B C = 12; required the length of the hypotenuse A C.

Here $\sqrt{}$ (A B^2 + B C^2) = $\sqrt{}$ (16^2 + 12^2) = $\sqrt{}$ (256 + 144) = $\sqrt{}$ 400 = $\sqrt{}$ 20^2 = 20, the length of the hypotenuse A C.



EXAMPLE 2.—Given the base A B = 16, and hypotenuse A C = 20; required the length of the perpendicular B C.

Here $\sqrt{\{(A\ C + A\ B) \times (A\ C - A\ B)\}} = \sqrt{\{(20 + 16) \times (20 - 16)\}} = \sqrt{(36 \times 4)} = \sqrt{(6^2 \times 2^2)} = 6 \times 2 = 12 =$ perpendicular B C = *Ans.*

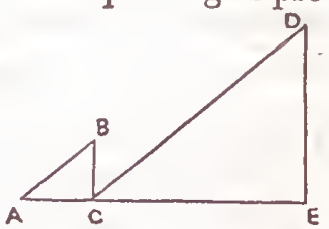
NOTE.—The diagonal line, or hypotenuse in a square, is equal to the square root of twice the square of the side. And the side of a square is equal to the square root of half the square of its diagonal.

Thus, suppose each side of a square equal 12 feet, find the diagonal.

Here (*by Fig.* 1, *page* 41) $\sqrt{(A\ B^2 \times 2)} = \sqrt{(12^2 \times 2)} = \sqrt{288} = 16{\cdot}97056$ feet, the diagonal from A to D.

Also, $\sqrt{(16{\cdot}97056^2 \div 2)} = \sqrt{(288 \div 2)} = \sqrt{144} = 12$ feet, the length of each side.

Similar triangles, or those which are equi-angular to each other, have the sides about their equal angles proportional; thus in the annexed figure the triangles A B C and C D E are similar, and, therefore, have the sides about the equal angles proportional,



AC : BC :: CE : DE;
AB : BC :: CD : DE, &c.

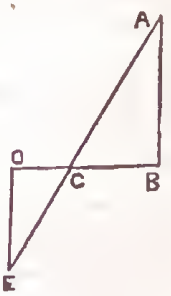
The utility, then, of the above triangles for practical purposes, as, for instance, ascertaining the heights of buildings, &c., will be seen from the following:—

Suppose D E to be an eminence, of which it is required to find the height, and E C the length of the shadow cast by the sun; then, in order to find D E, we may erect perpendicularly at C a pole of any known length, as B C, and after measuring the length of its shadow A C, state—as the length of the pole's shadow is to the height of the pole itself, so is the length of the shadow of D E to the height of D E; or,

As AC : CB :: CE : ED;

and supposing A C = 6 feet, B C = 4 feet, and C E = 30 feet, then E D would be 20 feet.

Again, supposing we wished to find the distance between two objects A and B; draw D B of any length at right angles to A B, and in D B take any point C, through which draw A E; also, at D, at right angles to D B, draw D E, making the triangle D E C, and state,



As DC : DE :: BC : BA.

PROBLEM V.

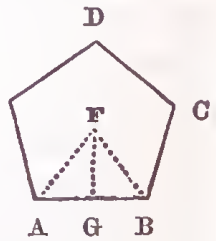
To find the area of any regular polygon from three to fifty sides.

RULE.—Multiply the sum of its sides by a perpendicular drawn from its centre to one of its sides, and take half the product for the area.

Or, multiply the square of the given side of a regular polygon by the numbers in the *sixth* column (*headed area of the polygon*), opposite its name and given number of sides, and the product will be the area.

EXAMPLE 1.—Required the area of the regular pentagon A B C D E, each side being 7·5, and perpendicular F G = 5·1614325. (*See Table, column* 6.)

Here $\frac{\text{sum of sides} \times \text{F G}}{2} = \frac{\text{AB} \times 5 \times \text{FG}}{2} = \frac{7{\cdot}5 \times 5 \times 5{\cdot}1614325}{2}$



= 96·77685, the area of the pentagon A B C D E.

EXAMPLE 2.—What is the area of a regular hexagon, each side being 8·75 in length? (*See Table, column* 6.)

Here $8{\cdot}75^2 \times 2{\cdot}598 = 199{\cdot}009375$, the area. = *Ans.*

Table of Multipliers for regular Polygons, from three to fifty Sides.

No. of Sides.	Name of the Polygon.	Radius of the circumscribing Circle, that of the inscribed being 1.	Side of the Polygon.	Radius of the circumscribing Circle, the side being 1.	Area of the Polygon.
3	Trigon	2·0000000	1·7320508	·5773503	·4330127
4	Tetragon	1·4142136	1·4142136	·7071068	1·0000000
5	Pentagon	1 2360680	1·1755706	·8506508	1·7204774
6	Hexagon	1·1547005	1·0000000	1·0000000	2·5980762
7	Heptagon	1·1099163	·8677676	1·1523825	3 6339126
8	Octagon	1·0823922	·7653668	1·3065630	4 8284272
9	Nonagon	1·0641778	·6840402	1·4619022	6·1818242
10	Decagon.....	1·0514622	·6180340	1·6180340	7·6942088
11	Undecagon	1·0422171	·5634652	1·7747331	9·3656415
12	Duodecagon	1·0352762	·5176380	1·9318517	11·1961524
13	Tridecagon	1·0299279	·4786312	2·0892913	13·1857718
14	Tetradecagon	1·0257169	·4450418	2·2469806	15·3345084
15	Pentadecagon	1·0223406	·4158234	2 4048672	17·6423629
16	Hexadecagon	1·0195912	·3901806	2·5629155	20·1093580
17	Heptadecagon	1·0173219	·3674990	2·7210970	22·7355038
18	Octadecagon.....	1·0154266	·3472964	2·8793853	25·5207681
19	Nonadecagon	1·0138273	·3291892	3·0377692	28·4652110
20	Eicosagon	1·0124651	·3128690	3·1962266	31·5687575
21	Uneicosagon.....	1·0112954	·2980846	3·3547557	34·8315014
22	Duoeicosagon	1·0102833	·2846296	3·5133383	38·2533531
23	Triseicosagon	1·0094016	·2723332	3·6719752	41·8344039
24	Tetreicosagon	1·0086290	·2610524	3·8306488	45·5745246
25	Penteicosagon	1·0079480	·2506664	3·9893649	49·4738444
26	Hexeicosagon	1·0073447	·2410734	4·1481206	53·5323900
27	Hepteicosagon.....	1·0068077	·2321858	4·3068951	57·7499409
28	Octeicosagon	1·0063276	·2239290	4·4657083	62 1268039
29	Noneicosagon	1·0058966	·2162380	4·6245414	66·6627662
30	Triacontagon	1·0055083	·2090570	4·7833861	71·3577338
31	Untriacontagon	1·0051571	·2023366	4 9422682	76·2121205
32	Duotriacontagon.....	1·0048386	·1960344	5 1011600	81·2255440
33	Tritriacontagon	1·0045487	·1901122	5·2600645	86·3980681
34	Tetratriacontagon ...	1·0042841	·1845368	5·4189880	91·7298172
35	Pentriacontagon	1·0040420	·1792786	5·5779245	97·2207110
36	Hextriacontagon.....	1·0038198	·1743114	5·7368565	102·8704680
37	Heptriacontagon.....	1·0036155	·1696120	5·8958213	108·6797596
38	Octriacontagon	1·0034272	·1651586	6·0547953	114·6481841
39	Nonatriacontagon ...	1·0032533	·1609332	6·2137666	120·7755354
40	Tesseracontagon	1·0030922	·1569182	6·3727475	127·0620500
41	Untesseracontagon ...	1·0029429	·1530984	6·5317653	133·5082939
42	Duotesseracontagon..	1·0028040	·1494602	6·6907572	140·1130227
43	Tritesseracontagon...	1·0026749	·1459906	6·8497696	146·8771694
44	Tetratesseracontagon	1·0025544	·1426784	7·0087998	153·8007306
45	Pentesseracontagon..	1·0024419	·1395130	7·1677935	160·8824925
46	Hextesseracontagon..	1·0023367	·1364848	7·3268444	168·1245663
47	Heptesseracontagon.	1·0022382	·1335852	7·4858794	175·5253176
48	Octesseracontagon ...	1·0021457	·1308062	7·6448940	183·0846240
49	Nonatesseracontagon	1·0020588	·1281404	7·8039765	190·8045888
50	Pentecontagon.....	1·0019772	·1255816	7·9629855	198·6818125

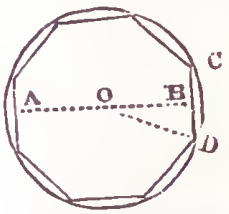
PROBLEM VI.

The side of a regular polygon being given, to find the radius of the circumscribing circle.

RULE.—Multiply the given side by that number in the fifth column of the table which is opposite the number of sides; the product will be the radius of the circumscribing circle.

EXAMPLE 3.—Required the radius O D of the circle circumscribing an octagon, the length of its side C D whereof is 7·6629502 *inches*. (*See Table, column* 5.)

Here D C × 1·3065630 = 7·6629502 × 1·3065630 *in.* = 10·0121272 *inches* = O D. = *Ans.*



PROBLEM VII.

The radius of a circle being given, to find the length of the side of a regular polygon inscribed in it.

RULE.—Multiply the given radius by that number in the fourth column of the table which is opposite the given number of sides; the product will be the length of the side.

EXAMPLE 4.—Given the radius O D = 10·0121272 *in.*, to find C D, the side of the inscribed octagon. (*See Table, column* 4.)

Here O D × ·7653668 = 10·0121272 × ·7653668 = 7·6629498 *inches* = C D. = *Ans.*

PROBLEM VIII.

The radius of the circle inscribed in a regular polygon being given, to find the radius of the circle circumscribing that polygon.

RULE.—Multiply the given inscribed radius by that number in the third column of the table which is oppo-

site to the given number of sides; the product will be the length of the required radius.

EXAMPLE 5.—The radius O B of the inscribed circle of an octagon being 9·25 *inches*, required the radius O D of the circumscribing circle. (*See Table, column* 3.)

Here O B × 1·0823922 = 9·25 × 1·0823922 *in.* = 10·0121278 *in.* = O D. = *Ans.*

PROBLEM IX.

Having the diameter of a circle given, to find the circumference; or the circumference given, to find the diameter.

RULE 1.—By the ratio of Archimedes—as 7 is to 22 so is the given diameter to the circumference.

And, as 22 is to 7 so is the circumference to the diameter; or, multiply the given circumference by ·318309*, the product will be the diameter *more nearly*.

2.—Write down the first three odd numbers, each twice, thus, 113355; separate these six figures into two parts, as 113 and 355, then we have the ratio of Metius —As 113 is to 355 so is the diameter to the circumference.

And, as 355 is to 113 so is the circumference to the diameter.

NOTE.—The ratio of the diameter of a circle to its circumference has never yet been *exactly* determined: if the diameter be 1, then will the circumference be

greater than 3·14159 2653
but less than 3·14159 2654.

The ratio of Archimedes is 1 to 3·14285 7143 nearly; that of Metius is 1 to 3·14159 2920 nearly.

To four places of decimals we may take 3·1416 as being sufficiently exact for most practical purposes.

EXAMPLE 1.—Required the circumference of a circle when the diameter is 23·5.

* This number is the reciprocal of 3·1416.

Here $\frac{23{\cdot}5 \times 22}{7} = \frac{517}{7} = 73\frac{6}{7}$, the circumference. = *Ans.*

EXAMPLE 2.—The circumference of a circle is $73\frac{6}{7}$, required the diameter.

Here $\frac{73\frac{6}{7} \times 7}{22} = \frac{517}{22} = 23{\cdot}5$, the diameter. = *Ans.*

EXAMPLE 3.—Required the circumference of a circle whose diameter is 30.

Here $\frac{355 \times 30}{113} = \frac{10650}{113} = 94{\cdot}248$, the circumference. = *Ans.*

EXAMPLE 4.—What is the diameter of a circle when the circumference is 94·248 ?

Here $94{\cdot}248 \div 3{\cdot}1416 = 30$, the diameter. = *Ans.*

Or thus, $\cdot 318309 \times 94{\cdot}248 = 29{\cdot}9999866$. = *Ans. as before.*

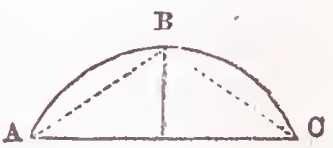
PROBLEM X.

To find the length of any arc of a circle.

RULE.—Subtract the chord of the whole arc from eight times the chord of half the arc; and $\frac{1}{3}$ of the remainder is the length of the arc *nearly*.

EXAMPLE.—Required the length of the arc A B C; the chord of half the arc A B = 19·8, and the chord A C of the whole arc = 34·4.

Here $\frac{(A\,B \times 8) - A\,C}{3} =$



$\frac{(19{\cdot}8 \times 8) - 34{\cdot}4}{3} = \frac{158{\cdot}4 - 34{\cdot}4}{3}$

$= \frac{124}{3} = 41{\cdot}3\dot{3}$, the length of the arc A B C. = *Ans.*

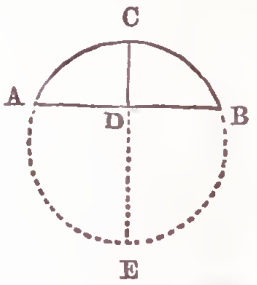
PROBLEM XI.

To find the diameter of a circle by having the chord and versed sine given.

RULE.—Divide the square of half the chord by the versed sine, to the quotient of which add the versed sine, and the sum will be the diameter.

Or, if the sum of the squares of the semichord and versed sine be divided by the versed sine, the quotient will be the diameter of the circle to which that segment corresponds.

EXAMPLE.—Given the chord A B = 24, and versed sine C D = 8; required the diameter of the circle C E.



Here $\left\{\left(\frac{A\,B}{2}\right)^2 \div C\,D\right\} + CD = (12^2 \div 8) + 8 = (144 \div 8) + 8 = 18 + 8 = 26$, the diameter. = *Ans.*

Or thus,

$\left\{\left(\frac{A\,B}{2}\right)^2 + C\,D^2\right\} \div 8 = (12^2 + 8^2) \div 8 = (144 + 64) \div 8 = 208 \div 8 = 26$, the diameter, *as before.*

PROBLEM XII.

To find the area of a parabola, or its segment.

RULE.—Multiply the base by the perpendicular height, and two-thirds of the product is the area.

EXAMPLE.—What is the area of a parabola, whose base is 20 feet, and perpendicular height 12?

Here $\frac{2}{3} \times 20 \times 12 = 2 \times 20 \times 4 = 160$ feet, the area.

Table of Versed Sines, in inches, quarters, and fractions of a quarter, by which to ascertain the diameters of circles corresponding to any segment or part of a circle having a chord of three feet.

Length of chord three feet.	Versed sine in inches.	Corresponding diameter in ft. and in.	Versed sine in inches.	Corresponding diameter in ft. and in.	Versed sine in inches.	Corresponding diameter in ft. and in
	in. qrs.	*ft. in.*	*in. qrs.*	*ft. in.*	*in. qrs.*	*ft. in.*
	6 .. 0	5 .. 0	2 .. 3	10 .. 0	1 .. 2	18 .. 0
	5 .. $2\frac{5}{8}$	5 .. 3	2 .. $2\frac{6}{8}$	10 .. 3	1 .. $1\frac{7}{8}$	18 .. 6
	5 .. $1\frac{3}{8}$	5 .. 6	2 .. $2\frac{4}{8}$	10 .. 6	1 .. $1\frac{6}{8}$	19 .. 0
	5 .. $0\frac{2}{8}$	5 .. 9	2 .. $2\frac{2}{8}$	10 .. 9	1 .. $1\frac{5}{8}$	19 .. 6
	4 .. $3\frac{2}{8}$	6 .. 0	2 .. 2	11 .. 0	1 .. $1\frac{4}{8}$	20 .. 0
	4 .. $2\frac{3}{8}$	6 .. 3	2 .. $1\frac{6}{8}$	11 .. 3	1 .. $1\frac{3}{8}$	21 .. 0
	4 .. $1\frac{5}{8}$	6 .. 6	2 .. $1\frac{4}{8}$	11 .. 6	1 .. $0\frac{7}{8}$	22 .. 0
	4 .. $0\frac{7}{8}$	6 .. 9	2 .. $1\frac{3}{8}$	11 .. 9	1 .. $0\frac{6}{8}$	23 .. 0
	4 .. $0\frac{2}{8}$	7 .. 0	2 .. $1\frac{1}{8}$	12 .. 0	1 .. $0\frac{4}{8}$	24 .. 0
	3 .. $3\frac{5}{8}$	7 .. 3	2 .. $0\frac{6}{8}$	12 .. 6	1 .. $0\frac{2}{8}$	25 .. 0
	3 .. 3	7 .. 6	2 .. $0\frac{3}{8}$	13 .. 0	1 .. $0\frac{1}{8}$	26 .. 0
	3 .. $2\frac{4}{8}$	7 .. 9	2 .. $0\frac{1}{8}$	13 .. 6	1 .. 0	27 .. 0
	3 .. 2	8 .. 0	1 .. $3\frac{6}{8}$	14 .. 0	0 .. $3\frac{7}{8}$	28 .. 0
	3 .. $1\frac{4}{8}$	8 .. 3	1 .. $3\frac{4}{8}$	14 .. 6	0 .. $3\frac{6}{8}$	29 .. 0
	3 .. $1\frac{1}{8}$	8 .. 6	1 .. $3\frac{2}{8}$	15 .. 0	0 .. $3\frac{5}{8}$	30 .. 0
	3 .. $0\frac{6}{8}$	8 .. 9	1 .. 3	15 .. 6	0 .. $3\frac{1}{8}$	35 .. 0
	3 .. $0\frac{3}{8}$	9 .. 0	1 .. $2\frac{6}{8}$	16 .. 0	0 .. $2\frac{6}{8}$	40 .. 0
	3 .. 0	9 .. 3	1 .. $2\frac{5}{8}$	16 .. 6	0 .. $2\frac{3}{8}$	45 .. 0
	2 .. $3\frac{5}{8}$	9 .. 6	1 .. $2\frac{3}{8}$	17 .. 0	0 .. $2\frac{1}{8}$	50 .. 0
	2 .. $3\frac{3}{8}$	9 .. 9	1 .. $2\frac{2}{8}$	17 .. 6		

Table of the relative Proportions of the Circle, its equal and inscribed squares.

1.	The Diameter of a circle ..	× ·8862	=	the side of an equal square.
2.	„ Circumference	× ·2821		
3.	„ Diameter	× ·7071	=	the side of an inscribed square.
4.	„ Circumference	× ·2251		
5.	„ Area.....	× ·6366	=	the area of an inscribed square.
6.	„ Side of inscribed square	× 1·4142	=	the diameter of a circumscribing circle.
7.	„ Side of inscribed square	× 4·443	=	the circumference of a circumscribing circle.
8.	„ Side of a square	× 1·128	=	the diameter of an equal circle.
9.	„ Side of a square	× 3·545	=	the circumference of an equal circle.

Examples illustrative of the preceding table.

EXAMPLE 1.—The diameter of a circle is 12·5; required the side of a square equal in area to the given circle.

Here 12·5 × ·8862 = 11·07750, side of equal square. = *Ans.*

Ex. 2.—The circumference of a circle being 53·4; required the side of a square equal in area.

Here 53·4 × ·2821 = 15·06414, side of equal square. = *Ans.*

Ex. 3.—The diameter of a circle being 18; required the side of the greatest square that can be inscribed therein.

Here 18 × ·7071 = 12·7278, side of inscribed square. = *Ans.*

Ex. 4.—The circumference of a circle is 86; required the side of inscribed square.

Here 86 × ·2251 = 19·3586, side of inscribed square. = *Ans.*

Ex. 5.—The area of a circle being 371·5; required the area of the greatest square that can be inscribed within the circle.

Here 371·5 × ·6366 = 236·49690, area of the square. = *Ans.*

Ex. 6.—The side of a square being 19·375; required the diameter of its circumscribing circle.

Here 19·375 × 1·4142 = 27·4001250, diameter. = *Ans.*

Ex. 7.—Required the circumference of a circle to circumscribe a square, each side being 19·375.

Here 19·375 × 4·443 = 86·083125, circumference of the circle. = *Ans.*

Ex. 8.—The side of a square being 13·5; required the diameter of a circle equal in area to the given square.

Here 13·5 × 1·128 = 15·228, diameter of the circle. = *Ans.*

Ex. 9.—The side of a square being 13·5; required the circumference of a circle equal in area to the given square.

Here $13{\cdot}5 \times 3{\cdot}545 = 47{\cdot}8575$, circumference of the circle. = *Ans.*

Some of the properties of a circle.

1.—It is the most capacious of all plain figures, or contains the greatest area within the same perimeter or outline.

2.—The areas of circles are to each other as the squares of their diameters, or of their radii.

3.—Any circle whose diameter is double that of another, contains four times the area of the other.

4.—The area of a circle is equal to the area of a triangle whose base is equal to the circumference, and perpendicular equal to the radius.

5.—The area of a circle is equal to the rectangle of its radius, and a right line equal to half its circumference.

6.—The area of a circle is found by squaring the diameter, and multiplying by ·7854; or by multiplying the circumference by the radius, and dividing the product by two.

Example 1.—Required the area of a circle, the diameter being 30·5.

Here $30{\cdot}5^2 \times {\cdot}7854 = 730{\cdot}618350$, the area required.

Example 2.—What is the area of a circle when the diameter is 1?

In this case the circumference is 3·1416, half of which is 1·5708, and half of $1 = {\cdot}5$; then $1{\cdot}5708 \times {\cdot}5 = {\cdot}7854$, the area.

PROBLEM XIII.

Having the area of a circle given, to find the diameter.

Rule.—Multiply the area by 452, and divide the product by 355, the square root of the product will be the diameter.

Or, multiply the square root of the area by 1·12838, and the product will be the diameter.

Or, divide the area by ·7854, and extract the square root.

EXAMPLE.—Required the diameter of that circle whose area is 122·71875.

Here $\sqrt{\frac{122{\cdot}71875 \times 452}{355}} = \sqrt{\frac{3927 \times 113}{2840}}$

$= \frac{\sqrt{(392{\cdot}7 \times 113 \times 284)}}{284} = \frac{\sqrt{12602528{\cdot}4}}{284} = \frac{3550}{284}$

$= 12{\cdot}5$ diameter. $=$ *Ans.*

Or thus, $\sqrt{}$ 122·71875 $= 11{\cdot}078$; and $11{\cdot}078 \times 1{\cdot}12838 = 12{\cdot}500194 = 12{\cdot}5$ diameter. $=$ *Ans. as before.*

PROBLEM XIV.

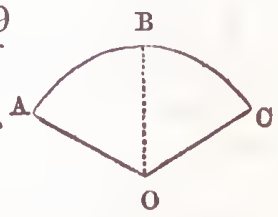
To find the area of a sector of a circle.

RULE.—Multiply the length of the arc by the radius of the circle, and half the product will be the area.

EXAMPLE.—Required the area of a sector of a circle whose arc A B C $= 26{\cdot}666$, and radius B O $= 16{\cdot}9$.

Here $\frac{\text{A B C} \times \text{B O}}{2} = \frac{26{\cdot}666 \times 16{\cdot}9}{2}$

$= \frac{450{\cdot}6554}{2} = 225{\cdot}3277$ the area of the sector A B C O A. $=$ *Ans.*

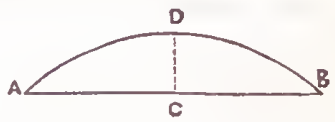


PROBLEM XV.

To find the area of a segment of a circle.

RULE.—Multiply the versed sine by ·626, to the square of the product add the square of half the chord (or multiply the square of the versed sine by ·391876, and to the product add the square of half the chord); multiply twice the square root of the sum by $\frac{2}{3}$ of the versed sine; and the product will be the area.

EXAMPLE.—Required the area of a segment of a circle whose chord A B = 48, and versed sine C D = 18.



Here $2 \times \surd \left[\cdot 391876 \times C\ D^2 + \left(\frac{A\ B}{2}\right)^2 \right] \times \frac{2\ C\ D}{3} = 2 \times \surd (\cdot 391876 \times 18^2 + 24^2) \times \frac{2 \times 18}{3}$ $= 24 \times \surd (\cdot 391876 \times 324 + 576) = 24 \times \surd (126 \cdot 967824 + 576) = 24 \times \surd 702 \cdot 967824 = 288 \times \surd 4 \cdot 881721 = 2 \cdot 20946 \times 288 = 636 \cdot 32448$ the area. = *Ans.*

The following is a near approximate to the preceding rule:

To the cube of the versed sine, divided by twice the length of the chord, add $\frac{2}{3}$ of the product of the chord, multiplied by the versed sine; and the sum will be the area of the segment nearly. Take the last example:—

Versed sine C D = 18, and chord A B = 48.

Here $\frac{C\ D^3}{2\ A\ B} + \frac{2 \times A\ B \times C\ D}{3} = \frac{18^3}{2 \times 48} + \frac{2 \times 48 \times 18}{3} = \frac{5832}{96} + 2 \times 48 \times 6 = 60 \cdot 75 + 576 = 636 \cdot 75$ the area *as before nearly.*

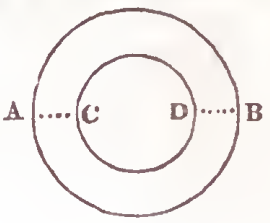
Or, the area of a segment may be found by finding the area of a sector having the same radius as the segment; then deducting the area of the triangle leaves the area of the segment.

PROBLEM XVI.

To find the area of a circular ring or space included between two concentric circles.

RULE.—Add the inside and outside diameters together, multiply the sum by their difference, and by ·7854, and the product will be the area.

EXAMPLE.—The diameters of two concentric circles, A B and C D, are 10 and 6; required the area of the ring or space contained between them.



Here (A B + C D) + (A B − C D) × ·7854 = (10 + 6) × (10 − 6) × ·7854 = 16 × 4 × ·7854 = 50·2656 the area. = *Ans.*

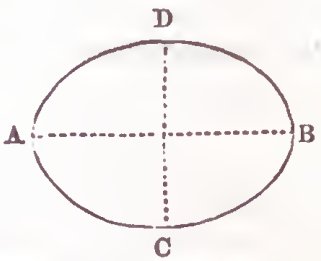
PROBLEM XVII.

To find the area of an ellipse.

RULE.—Multiply the transverse or longer diameter by the conjugate or shorter diameter, and by ·7854, and the product will be the area.

EXAMPLE.—Required the area of an ellipse whose longer diameter A B = 12, and shorter diameter C D = 9.

Here A B × C D × ·7854 = 12 × 9 × ·7854 = 84·8232 the area. = *Ans.*



NOTE.—If half the sum of the two diameters be multiplied by 3·1416, the product will be the circumference of the ellipse, *near enough for most practical purposes.*

Thus ½ (A B + C D × 3·1416) = ½ (12 + 9) × 3·1416 = 21 × 1·5708 = 32·9868, the circumference required.

MENSURATION OF SOLIDS.

By solids are meant all bodies, whether solid, fluid, or bounded space, that can be comprehended within length, breadth, and thickness.

PROBLEM I.

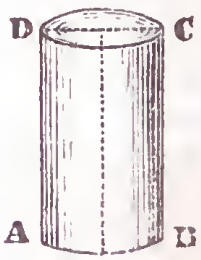
To find the convex surface and solid content of a cylindrical cylinder, or any figure of a cubical form.

RULE 1.—Multiply the circumference of the base by the height of the cylinder, and the product is the convex surface.

RULE 2.—Multiply the area of the base by the height of the cylinder, and the product is the solid content.

EXAMPLE 1.—Required the convex surface of the cylinder A B C D, whose base A B = 32 inches, and perpendicular height B C = 6 feet.

Here $3{\cdot}1416 \times A\,B \times B\,C = 3{\cdot}1416 \times 32 \times 72$ inches = 7238·2464 square or superficial inches, and $7238{\cdot}2464 \div 144 =$ 50·2656 superficial feet. = *Ans.*



EXAMPLE 2.—Required the solid content, in cubic inches and cubic feet, of the same cylinder as in Example 1.

Here $(A\,B^2 \times {\cdot}7854) \times B\,C = (32^2 \times {\cdot}7854) \times 72 = 1024 \times {\cdot}7854 \times 72 = 57905{\cdot}9712$ cubic inches, and $57905{\cdot}9712 \div 1728 = 33{\cdot}5104$ cubic feet.

EXAMPLE 3.—Suppose the cylinder A B C D be intended to contain a fluid, and that the sides and bottom

are each one inch in thickness, how many imperial gallons would it contain?

Here $\{[(\text{A B}-2\,in.)^2 \times \cdot7854] \times (\text{B C}-1\,in.)\} \div 277{\cdot}274 = \{[(32-2)^2 \times \cdot7854] \times (72-1)\} \div 277{\cdot}274 = (30^2 \times \cdot7854 \times 71) \div 277{\cdot}274 = (900 \times \cdot7854 \times 71) \div 277{\cdot}274 = 50187{\cdot}06\,cubic\,in. \div 277{\cdot}274 = 181$ imperial gallons. = *Ans.*

Or, since the reciprocal of $1 \div 277{\cdot}274 = \cdot003607$, therefore 50187·06 *cubic in.* × ·003607 = 181 imperial gallons. = *Ans. as before.*

PROBLEM II.

To determine the dimensions of any cylindrical vessel, whereby to contain the greatest cubical contents, bounded by the least superficial surface.

Rule.—Multiply the given cubical contents by 2·5465, and the cube root of the product will equal the diameter, and half the diameter equal the depth.

Example 1.—Suppose a cylindrical vessel is to be made so as to contain 600 cubic feet, and of such dimensions as to require the least possible materials by which it is constructed, what must be its depth and diameter?

Here $\sqrt[3]{(600 \times 2{\cdot}5465)} = \sqrt[3]{1527{\cdot}9} = 11{\cdot}5177$ feet diameter, and $11{\cdot}5177 \div 2 = 5{\cdot}75885$ feet in depth.

Note.—If the vessel is to be made with two ends, then the cube root of four times the solidity divided by 3·1416 will equal both the length and diameter, so as to require the least possible quantity of materials in its construction.

Example 2.—Suppose a cylindrical vessel is to be made with two ends, so as to contain 600 cubic feet, as in Example 1; required its depth and diameter, so that it may be constructed with the least possible quantity of materials.

Here $\sqrt[3]{\left(\frac{600 \times 4}{3{\cdot}1416}\right)} = \sqrt[3]{764} = 9{\cdot}1418$, the depth and diameter in feet, as required.

Or thus,

$\sqrt[3]{(600 \times 4 \times {\cdot}318309)} = \sqrt[3]{763{\cdot}941600} = 9{\cdot}1416$, the *Ans. as before, nearly.*

PROBLEM III.

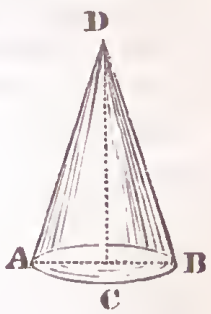
To find the surface and solid content of a cone or pyramid.

RULE 1.—Multiply the circumference of the base by the slant height, and half the product will be the slant surface; to which add the area of the base, and the product will be the whole surface.

RULE 2.—Multiply the area of the base by the perpendicular height, and $\frac{1}{3}$ of the product will be the solid content.

EXAMPLE 1.—Required the convex surface of a cone whose base A B = 20 inches, and slant height B D = 29·5.

Here $\frac{1}{2}$ (3·1416 × A B × B D) = $\frac{1}{2}$ (3·1416 × 20 × 29·5) = 3·1416 × 10 × 29·5 = 926·772 square inches, which divided by 144 = 6·436 superficial feet. = *Ans.*



EXAMPLE 2.—Required the solidity of the cone as above, taking the perpendicular C D at 28 inches.

Here $\frac{1}{3}$ (·7854 × A B² × C D) = $\frac{1}{3}$ (·7854 × 20² × 28) = 2932·16 cubic inches, which divided by 1728 = 1·697 cubic feet. = *Ans.*

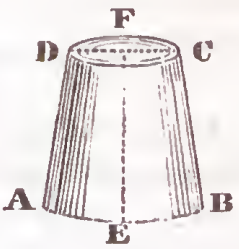
PROBLEM IV.

To find the surface of the frustum of a cone or pyramid.

RULE.—Multiply the sum of the perimeters of the

two ends by the slant height, and half the product will be the slant surface; to which add the areas of the two ends, and the product will be the whole surface.

EXAMPLE.—Required the convex surface of the frustum of a cone A B C D, whose base A B = 20 inches, the slant height B C = 19, and top end C D = 11 inches.



Here $\frac{1}{2}$ [(3·1416 × A B) + (3·1416 × D C) × B C] = $\frac{1}{2}$ [3·1416 × (A B + D C) × B C] = $\frac{1}{2}$ [3·1416 × (20 + 11) × 19] = 1·5708 × 31 × 19 = 925·2012 square inches, which divided by 144 = 6·425 square feet. = *Ans.*

PROBLEM V.

To find the solid content of the frustum of a cone.

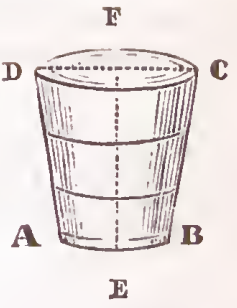
RULE.—To the product of the diameters of the two ends, add the sum of their squares; multiply this sum by the perpendicular height, and by ·2618, the product is the solid content.

EXAMPLE 1.—Required the solid content of the frustum of a cone in Problem IV., whose perpendicular E F taken = 18 inches, D C = 11 inches, and A B = 20 inches.

Here (A B × D C + A B^2 + D C^2) × E F × ·2618 = (20 × 11 + 20^2 + 11^2) × 18 × ·2618 = (220 + 400 + 121) × 18 × ·2618 = 741 × 18 × ·2618 = 3491·8884 cubic inches, which divided by 1728 = 2·0208 cubic feet. = *Ans.*

EXAMPLE 2.—Required the content, in imperial gallons, of the inverted frustum of a cone A B C D, whose inner dimensions are E F = $3\frac{1}{2}$ feet deep, D C = 18 inches diameter at bottom, and A B = 22 inches diameter at top.

Here $\{(A\,B \times D\,C + A\,B^2 + D\,C^2) \times E\,F \times \cdot2618\} \div 277\cdot274 = \{(18 \times 22 + 18^2 + 22^2) \times 42 \times \cdot2618\} \div 277\cdot274 = \{(396 + 324 + 484) \times 42 \times \cdot2618\} \div 277\cdot274 = (1204 \times 42 \times \cdot2618) \div 277\cdot274 = 13238\cdot7024$ *cub. in.* $\div 277\cdot274 = 47\cdot746$ imperial gallons. = *Ans.*



Or thus,

$13238\cdot7024 \times 0\cdot00360654 = 47\cdot746$ imperial gallons. = *Ans. as before.*

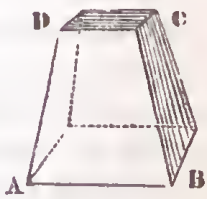
PROBLEM VI.

To find the solid content of the frustum of a pyramid.

RULE.—To the sum of the areas of the two ends, add the square root of their product; multiply this sum by the perpendicular height, and $\frac{1}{3}$ of the product is the solid content.

EXAMPLE.—Required the solid content of the frustum of a pyramid A B C D, whose perpendicular height = 24 inches, the area of the base A B = 144 square inches, and area of the top end D C = 64 square inches.

Here $\{[\text{area at A B} + \text{area at D C} + \surd(\text{area at A B} \times \text{area at D C})] \times \text{perp. height}\} \div 3 = \{[144 + 64 + \surd(144 \times 64)] \times 24\} \div 3 = \{208 + \surd(12^2 \times 8^2)\} \times 8 = (208 + 12 \times 8) \times 8 = (208 + 96) \times 8 = 304 \times 8 = 2432$ cubic inches, which $\div 1728 = 1\cdot4074$ cubic feet. = *Ans.*



PROBLEM VII.

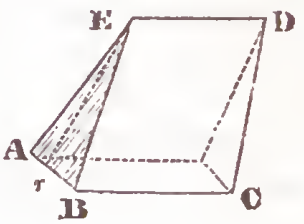
To find the solidity of a wedge.

RULE.—To the length of the edge add twice the length of the base; multiply that sum by the perpen-

dicular height, and by the breadth of the base, and one-sixth of the product will be the solidity.

EXAMPLE.—Required the content in cubic inches of the wedge A B C D E, whose base A B C is 12 inches long and 4 inches broad, the length of the edge D E = 10 inches, and perpendicular height r E = 20 inches.

Here $\{(E D + 2 \times B C) \times E r \times A B\} \div 6 = \{(10 + 2 \times 12) \times 20 \times 4\} \div 6 = \{(10 + 24) \times 80\} \div 6 = (34 \times 80) \div 6 = 2720 \div 6 = 453{\cdot}3'$ cubic inches. = *Ans.*



PROBLEM VIII.

To find the convex surface and solid content of a sphere or globe.

RULE 1.—Multiply the square of the diameter by 3·1416, the product will be the convex superficies.

RULE 2.—Multiply the cube of the diameter by ·5236, and the product is the solid content.

EXAMPLE 1.—Required the convex surface of a sphere, whose diameter A B = $25\frac{1}{2}$ inches.

Here $A B^2 \times 3{\cdot}1416 = 25{\cdot}5^2 \times 3{\cdot}1416 = 2042{\cdot}8254$ square inches, which ÷ 144 = 14·1863 square or superficial feet. = *Ans.*

EXAMPLE 2.—Required the solid content of a sphere, whose diameter A B = $25\frac{1}{2}$ inches.

Here $A B^3 \times {\cdot}5236 = 25{\cdot}5^3 \times {\cdot}5236 = 8682{\cdot}00795$ cubic inches, which divided by 1728 = 5·0243 cubic feet. = *Ans.*

PROBLEM IX.

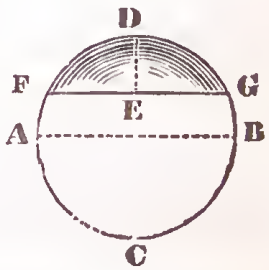
To find the convex surface and solid content of the segment of a sphere.

RULE 1.—Multiply the height of the segment by the whole circumference of the sphere, and the product is the curved surface.

RULE 2.—Add the square of the height to three times the square of the radius of the base; multiply that sum by the height, and by ·5236, and the product is the solid content.

EXAMPLE 1.—The diameter A B of the sphere A B C D = 20 inches, what is the convex surface of that segment of it, whose height E D = 8 inches?

Here 3·1416 × A B × E D = 3·1416 × 20 × 8 = 502·656 square inches, which ÷ 144 = 3·49 superficial feet. = *Ans.*

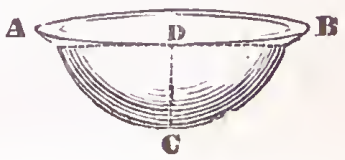


EXAMPLE 2.—The diameter of the base F G of the segment F D G = 18 inches, and perpendicular E D = 8, what is the solid content?

Here (E D^2 + 3 F E^2) × D E × ·5236 = (8^2 + 3 × 9^2) × 8 × ·5236 = (64 + 243) × 8 × ·5236 = 307 × 8 × ·5236 = 1285·9616 cubic inches, which divided by 1728 = ·7442 cubic feet. = *Ans.*

EXAMPLE 3.—Suppose A B C D to be a sugar pan, and that the diameter of the mouth A B is 4 feet, the depth D C being 25 inches, how many imperial gallons will it contain?

Here {D C^2 + (half A B)^2 × 3} × D C × ·5236 = (25^2 + 24^2 × 3) × 25 × ·5236 = (625 + 576 × 3) × 25 × ·5236



$= (625 + 1728) \times 25 \times \cdot5236 = 2353 \times 25 \times \cdot5236 = 30800\cdot77$ cubic inches, which divided by $277\cdot274 = 111\cdot084$ imperial gallons. = *Ans.*

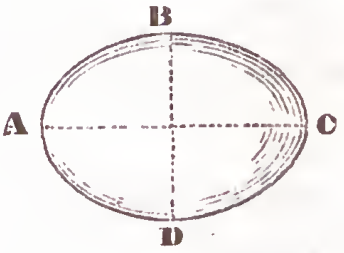
PROBLEM X.

To find the solidity of a spheroid *.

RULE.—Multiply the square of the revolving axis by the fixed axis, and by ·5236, and the product will be the solidity.

EXAMPLE 1.—Required the solid content of the prolate spheroid A B C D, whose fixed axis A C = 50, and revolving axis B D = 30.

Here $B D^2 \times A C \times \cdot5236 = 30^2 \times 50 \times \cdot5236 = 23562$, the solidity. = *Ans.*



EXAMPLE 2.—What is the solid content of an oblate spheroid, the fixed axis B D = 30, and revolving axis A C = 50?

Here $A C^2 \times B D \times \cdot5236 = 50^2 \times 30 \times \cdot5236 = 39270$, the solid content. = *Ans.*

PROBLEM XI.

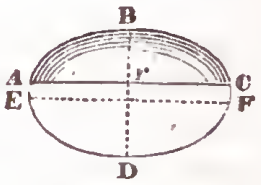
To find the solidity of the segment of a spheroid when the base is circular or parallel to the revolving axis.

RULE.—From triple the fixed axis take double the height of the segment; multiply the difference by the square of the height, and by ·5236; then, as the square of the fixed axis is to the square of the revolving axis, so is the former product to the solidity.

---

* A spheroid is a solid body generated by an ellipse revolving about one of its axes; when it revolves about the transverse or major axis, the solid thus generated is called a *prolate* spheroid; when the revolution revolves about the conjugate or minor axis, it is called an *oblate* spheroid.

EXAMPLE 1.—Required the solid content of the segment A B C, whose height B r is 10, the revolving axis E F = 40, and fixed axis B D = 25.



Here $BD^2 : EF^2 :: (3BD - 2Br) \times Br^2 \times .5236 : [(3BD - 2Br) \times Br^3 \times .5236 \times EF^4] \div BD^2 = [(3 \times 25 - 2 \times 10) \times 10^2 \times .5236 \times 40^2] \div 25^2 = [(75 - 20) \times 100 \times .5236 \times 1600] \div 625 = (55 \times 52{\cdot}36 \times 64) \div 25 = (220 \times 52{\cdot}36 \times 64) \div 100 = 22 \times 5{\cdot}236 \times 64 = 7372{\cdot}288$. = *Ans.*

EXAMPLE 2.—What is the solid content of the segment of a spheroid, whose height B r = 20 inches, the revolving axis E F = 25 inches, and fixed axis B D = 50 inches?

Here $BD^2 : EF^2 :: (3BD - 2Br) \times Br^2 \times .5236 : [(3BD - 2Br) \times Br^2 \times .5236 \times EF^2] \div BD^2 = [(3 \times 50 - 2 \times 20) \times 20^2 \times .5236 \times 25^2] \div 50^2 = [(150 - 40) \times 400 \times .5236 \times 625] \div 2500 = (110 \times 52{\cdot}36 \times 2500) \div 2500 = 110 \times 52{\cdot}36 = 5759{\cdot}6$ cubic inches, the solid content. = *Ans.*

PROBLEM XII.

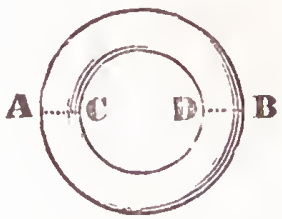
To find the convex surface and solid content of a cylindric ring.

RULE 1.—To the thickness of the ring, add the inner diameter; multiply the sum by the thickness, and by 9·8696, and the product will be the convex surface.

RULE 2.—To the thickness of the ring, add the inner diameter; multiply that sum by the square of the thickness, and by 2·4674, and the product will be the solid content.

EXAMPLE 1.—The thickness of a cylindric ring A C or D B = 2 inches, and inner diameter = 18 inches, required the convex superficies.

Here (A C + C D) × A C × 9·8696 = (2 + 18) × 2 × 9·8696 = 20 × 2 × 9·8696 = 394·784 square inches, which ÷ 144 = 2·742 superficial feet. = *Ans.*



EXAMPLE 2.—Required the solid content of the ring as above.

Here (A C + C D) × A C^2 × 2·4674 = (18 + 2) × 2^2 × 2·4674 = 20 × 4 × 2·4674 = 197·392 cubic inches, which ÷ 1728 = ·114 cubic feet. = *Ans.*

NOTE.—A cubic foot is equal to 1728 cubic inches;
or 2200 cylindrical inches;
or 3300 spherical inches;
or 6600 conical inches.

Also, the cubic foot being considered unity, or 1,
A cylinder 1 foot diameter, and 1 foot in length = ·7854
A sphere 1 foot in diameter ..... = ·5236
And a cone 1 foot diameter at the base and 1 foot in height ..... = ·2618.

OF TIMBER MEASURE.

Timber is chiefly estimated by the square or superficial foot of 144 inches, or cubic foot of 1728; the calculation of which is performed by duodecimals; that is, the foot or inch, &c., divided into 12 parts or divisions, thus:—

12 fourths	make	1 third.
12 thirds	„	1 second.
12 seconds	„	1 inch.
12 inches	„	1 foot.

And the several values arising are:—

Feet multiplied by feet give feet,
Feet multiplied by inches give inches,
Feet multiplied by seconds give seconds,
Inches multiplied by inches give seconds,
Inches multiplied by seconds give thirds,
Seconds multiplied by seconds give fourths, &c.

But this rule is more commonly called Cross Multiplication, on account of commencing with the left-hand figure of the multiplier.

To find the superficial content of timber.

Rule 1.—Place the multiplier under the multiplicand, feet under feet, inches under inches, seconds under seconds, &c.

2.—Multiply each denomination of the length by the feet of the breadth, beginning at the lowest, and place each product under that denomination of the multiplicand from which it arises, always carrying one for every 12.

3.—Multiply by the inches, and set each product one place farther to the right hand.

4.—Then multiply by the seconds, and set each product another place toward the right hand, &c.

Thus proceed in like manner with all the other denominations, and their sum will be the content.

EXAMPLE 1.—Required the superficial content of a board 12 feet 6 inches long and 1 foot $5\frac{1}{2}$ inches broad.

	ft.	*in.*	
	12	. 6	
Multiplied by	1	. 5	. 6
	12	. 6	
	5	. 2	. 6
		6	. 3
Ans. =	18	. 2	. 9

When the two ends of a board or plank are of different breadths, add the two breadths together, and multiply the length by half the sum.

EXAMPLE 2.—A plank is 1 foot 4 inches broad at one end, $11\frac{1}{2}$ inches broad at the other, and 18 feet 9 inches long, what is its superficial content?

Here $(16 + 11\frac{1}{2}) \div 2 = 27\frac{1}{2} \div 2 = 13\frac{3}{4}$ inches.

	ft.	*in.*	
Then	18	. 9	
$13\frac{3}{4}$ inches =	1	. 1	. 9
	18	. 9	
	1	. 6	. 9
	1	. 2	. 0 . 9
Ans. =	21	. 5	. 9 . 9

Superficial measure by the Engineer's Slide Rule.

When the length is given in feet, and the breadth in inches, the gauge point is 12; but if the dimensions are all inches, the gauge point is 144.

RULE.—Set the breadth upon B to the gauge point upon A, and against the length upon A is the content in square feet upon B.

EXAMPLE 1.—Required the number of square feet contained in a board $11\frac{1}{2}$ inches broad and 18 feet long.

Set 11·5 upon B to 12 upon A; and against 18 upon A is 17·3 feet upon B.

The content of one board being found, the content of any number of the same dimensions may be found by setting 1 upon B to the content of the one found upon A; and against any number of boards upon B is the whole content upon A.

Find the content of 8 boards, each being 17·3 square feet.

Set 1 upon B to 17·3 upon A; and against 8 upon B is 138·4 feet upon A.

EXAMPLE 2.—If a board is 10 inches broad at one end, and 7 inches at the other, what must be its length to make a square foot?

Here $(10 + 7) \div 2 = 17 \div 2 = 8\frac{1}{2}$ inches. Set 8·5 upon B to 144 upon A; and against 1 upon B is 16·9 inches long upon A.

To find the solidity of timber.

The solid content of timber (according to custom) is found by multiplying the length by the square of the $\frac{1}{4}$ girth.

EXAMPLE.—Required the content of a tree in cubic feet, whose girth in the middle is 84 inches, and length 25 feet 6 inches.

Here $84 \div 4 = 21$ inches $= \frac{1}{4}$ girth.

	ft.	*in.*
and 21 inches =	1	9
Multiplied by	1	9
	1	9
	1	3 . 9
Ans. =	3	0 . 9

	ft.	*in.*
Then	25	6
Multiplied by	3	0 . 9
	76	6
	1	7 . 1 . 6
Ans. =	78	1 . 1 . 6

But a more expeditious method is obtained by means of the following

TABLE.

¼ Girth in Inches.	Area in Feet	¼ Girth in Inches.	Area in Feet.	¼ Girth in Inches	Area in Feet.
6	·25000	12¼	1·04210	19	2·50694
6¼	·27127	12½	1·08507	19½	2·64063
6½	·29340	12¾	1·12891	20	2·77777
6¾	·31641	13	1·17361′	20½	2·91840
7	·34028	13¼	1·21918	21	3·06250
7¼	·36502	13½	1·26563	21½	3·21007
7½	·39063	13¾	1·31293	22	3·36111′
7¾	·41710	14	1·361′11	22½	3·51563
8	·4′4444	14¼	1·41016	23	3·67361
8¼	·47266	14½	1·46007	23½	3 83507
8½	·50174	14¾	1·51085	24	4·00000
8¾	·53168	15	1·56250	24½	4·16840
9	·56250	15¼	1·61502	25	4·34028
9¼	·59418	15½	1·66840	25½	4·51563
9½	·62647	15¾	1·72266	26	4·694′44
9¾	·66016	16	1·77777	26½	4·87674
10	·694′44	16¼	1·83377	27	5·06250
10¼	·72960	16½	1·89063	27½	5·25174
10½	·76563	16¾	1·94835	28	5·4′4444
10¾	·80252	17	2·00694	28½	5·64063
11	·84028	17¼	2·06641	29	5·84028
11¼	·87891	17½	2·12674	29½	6·04340
11½	·91840	17¾	2·18793	30	6·25000
11¾	·95877	18	2·25000	31	6·67361
12	1·00000	18½	2·37674	32	7·1′1111

Rule.—Multiply the area corresponding to the ¼ girth in inches by the length of the timber in feet; and the product is the solidity in feet and decimal parts.

Example.—A piece of timber 18 feet long and 14 inches square, how many cubic feet does it contain?

Here 1·361′ × 18 = 24·5 cubic feet.

By the Slide Rule.

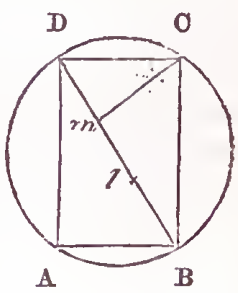
Set the length in feet upon B to 144 upon A; and against the square, or $\frac{1}{4}$ girth upon D, is the solid content in feet upon C.

EXAMPLE.—How many cubic feet are contained in a tree 28 feet long and 16 inches $\frac{1}{4}$ girth?

Set 28 upon B to 144 upon A; and against 16 upon D is 49·8 feet upon C.

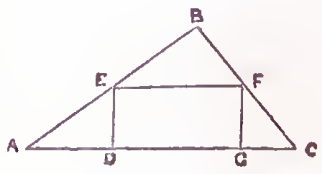
To find the transverse section of the strongest beam that can possibly be cut out of a round piece of timber.

Let the circle A B C D be the transverse section of the piece of timber given, draw the diameter B D, and divide it into three equal parts, as B *l* *m* D, erect the perpendicular *m* C, meeting the circle in C, draw D C and C B; then draw the chord A B parallel to D C, join A D, and the rectangle A B C D will be a section of the beam as required.



To determine the greatest rectangle that can possibly be obtained in a given triangle.

Let A B C be a given triangle, bisect any two of its sides, as E F; join E F, to each end of which draw lines at right angles with the other side A C, and D E F G will be the rectangle required.



ON THE STRENGTH OF MATERIALS.

A knowledge of the strength of materials is one of the most important, and at the same time one of the most difficult subjects that the practical mechanic has to contend with, owing chiefly to the very different qualities of bodies of the same name; hence arise some doubts in selecting experiments whereon to build the data, there being scarcely two experiments made producing the same results. However, the following tables and rules are founded upon a mean of Messrs. Rennie, Barlow, and Telford's experiments, having found them to agree the best with practice, and my own experiments on similar bodies.

ON THE COHESIVE STRENGTH OF BODIES.

The cohesive strength of a body is that force with which it resists separation in the direction of its length, as in the case of ropes, &c.; and no reason can be assigned why the strength should not vary directly as the section of fracture, and is totally independent of the length in position, except so far as the weight of the body may increase the force applied: neglecting this, and supposing the body uniform in all its parts, the strength of bodies exposed to strains in the direction of their length is directly proportionate to their transverse area, whatever be their figure, length, or position.

The following Table contains the result of experiments on the cohesive strength of various bodies in avoirdupois pounds; also one-third of the ultimate strength of each body, this being considered sufficient, in most cases, for a permanent load.

Names of Bodies.	*Square or rectangular Bar.*	*One Third*	*Round Bar.*	*One Third.*
WOODS.	*lbs.*	*lbs.*	*lbs.*	*lbs.*
Boxwood	20000	6667	15708	5236
Ash.....	17000	5667	13357	4452
Teak	15000	5000	11781	3927
Fir	12000	4000	9424	3141
Beech.....	11500	3833	9032	3011
Oak	11000	3667	8639	2880
METALS.				
Cast iron	18656	6219	14652	4884
English wrought iron	55872	18624	43881	14627
Swedish ditto	72064	24021	56599	18866
Blistered steel	133152	44384	104577	34859
Shear ditto	124400	41467	97703	32568
Cast ditto	134256	44752	105454	35151
Cast copper	19072	6357	14979	4993
Wrought ditto	33792	11264	26540	8847
Yellow brass	17968	5989	14112	4704
Cast tin	4736	1579	3719	1240
Cast lead	1824	608	1432	477

PROBLEM I.

To find the ultimate cohesive strength of square, round, and rectangular bars, of any of the various bodies, as specified in the table.

RULE.—Multiply the strength of an inch bar (as in the table), of the body required, by the cross sectional area of square and rectangular bars, or by the square of the diameter of round bars; and the product will be the ultimate cohesive strength.

EXAMPLE 1.—A bar of cast iron being $1\frac{1}{2}$ inches square, required its cohesive power.

Here $1{\cdot}5 \times 1{\cdot}5 \times 18656$ *lbs.* $= 41976$ *lbs.* $=$ *Ans.*

EXAMPLE 2.—Required the cohesive force of a bar of English wrought iron, 2 inches broad, and $\frac{3}{8}$ of an inch in thickness.

Here $2 \times \cdot 375 \times 55872$ *lbs.* $= 41904$ *lbs.* $=$ *Ans.*

EXAMPLE 3.—Required the ultimate cohesive strength of a round bar of wrought copper, $\frac{3}{4}$ of an inch in diameter.

Here $\cdot 75^2 \times 26540$ *lbs.* $= 14928 \cdot 75$ *lbs.* $=$ *Ans.*

PROBLEM II.

The weight of a body being given, to find the cross sectional dimensions of a bar or rod capable of sustaining that weight.

RULE.—For square and round bars,—Divide the weight given by one-third of the cohesive strength of an inch bar (as specified in the table), and the square root of the quotient will be the side of the square, or diameter of the bar in inches.

And if rectangular, divide the quotient by the breadth, and the result will be the thickness.

EXAMPLE 1.—What must be the side of a square bar of Swedish iron to sustain a permanent weight of 18000 *lbs.?*

Here $\sqrt{\frac{18000}{24021}} = \sqrt{\cdot 7493} = \cdot 87$, or nearly $\frac{7}{8}$ of an inch square. $=$ *Ans.*

EXAMPLE 2.—Required the diameter of a round rod of cast copper to carry a weight of 6800 *lbs.*

Here $\sqrt{\frac{6800}{4993}} = \sqrt{1 \cdot 3619} = 1 \cdot 16$ inches diameter. $=$ *Ans.*

EXAMPLE 3.—A bar of English wrought iron is to be applied to carry a weight of 2760 *lbs.;* required the thickness, the breadth being two inches.

$\frac{1}{2}\left(\frac{2760}{18624}\right) = \frac{1}{2}\left(\frac{115}{776}\right) = \frac{57 \cdot 5}{776} = \cdot 074$ of an inch in thickness. $=$ *Ans.*

A TABLE

Showing the circumference of a rope equal to a chain made of iron of a given diameter, and the weight in tons that each is proved to carry; also the weight of a foot of chain made from iron of that dimension.

Ropes. Circumference in inches.	*Chains. Diameter in inches.*	*Proved to carry in tons.*	*Weight of a lineal foot in lbs. Avr.*
3	$\frac{1}{4} + \frac{1}{16}$	1	1·08
4	$\frac{3}{8}$	2	1·5
$4\frac{3}{4}$	$\frac{3}{8} + \frac{1}{16}$	3	2
$5\frac{1}{4}$	$\frac{1}{2}$	4	2·7
6	$\frac{1}{2} + \frac{1}{16}$	5	3·3
$6\frac{1}{2}$	$\frac{5}{8}$	6	4
7	$\frac{5}{8} + \frac{1}{16}$	8	4·6
$7\frac{1}{2}$	$\frac{3}{4}$	$9\frac{3}{4}$	5·5
8	$\frac{3}{4} + \frac{1}{16}$	$11\frac{1}{4}$	6·1
9	$\frac{7}{8}$	13	7·2
$9\frac{1}{2}$	$\frac{7}{8} + \frac{1}{16}$	15	8·4
$10\frac{1}{2}$	1 inch.	18	9·4

ON THE TRANSVERSE STRENGTH OF BODIES

The *transverse strength* of a body is that power which it exerts in opposing any force acting in a perpendicular direction to its length, as in the case of beams, levers, &c., for the fundamental principles of which observe the following:—

That the transverse strength of beams, &c., is inversely as their lengths, and directly as their breadths and square of their depths, and, if cylindrical, as the cubes of their diameters; that is, if a beam 6 feet long, 2 inches broad, and 4 inches deep, can carry 2000 *lbs.*, another beam of the same material, 12 feet long, 2 inches broad, and 4 inches deep, will only carry 1000, being inversely as their lengths. Again, if a beam 6 feet long, 2 inches broad, and 4 inches deep, can sup-

port a weight of 2000 *lbs.*, another beam of the same material, 6 feet long, 4 inches broad, and 4 inches deep, will support double that weight, being directly as their breadths;—but a beam of that material, 6 feet long, 2 inches broad, and 8 inches deep, will sustain a weight of 8000 *lbs.;* being as the square of their depths.

From a mean of experiments made to ascertain the transverse strength of various bodies, it appears that the ultimate strength of an inch square, and an inch round bar of each, 1 foot long, loaded in the middle, and lying loose at both ends, is nearly as follows, in *lbs.* avoirdupois.

Names of Bodies.	*Square Bar.*	*One Third.*	*Round Bar.*	*One Third.*
Oak	800	267	628	209
Ash	1137	379	893	298
Elm	569	190	447	149
Pitch pine	916	305	719	240
Deal	566	189	444	148
Cast iron	2580	860	2026	675
Wrought iron	4013	1338	3152	1051

PROBLEM I.

To find the ultimate transverse strength of any rectangular beam, supported at both ends, and loaded in the middle; or supported in the middle, and loaded at both ends; also, when the weight is between the middle and the end; likewise, when fixed at one end, and loaded at the other.

RULE.—Multiply the strength of an inch square bar, 1 foot long (as in the table), by the breadth, and square of the depth in inches, and divide the product by the length in feet; the quotient will be the weight in *lbs.* avoirdupois.

EXAMPLE 1.—What weight will break a beam of oak, 4 inches broad, 8 inches deep, and 20 feet between the supports?

Here $\frac{800 \times 4 \times 8^2}{20} = 40 \times 4 \times 64 = 10240$ *lbs.* $=$ *Ans.*

NOTE.—When a beam is supported in the middle, and loaded at each end, it will bear the same weight as when supported at both ends, and loaded in the middle; that is, each end will bear half the weight.

When the weight is not situated in the middle of the beam, but placed somewhere between the middle and the end,—Divide four times the product of the two distances of the weight from the two ends by the whole length of the beam. The quotient will be the effective length.

EXAMPLE 2.—Required the ultimate transverse strength of a pitch pine plank, 24 feet long, 3 inches broad, 7 inches deep, and the weight placed 8 feet from one end.

Here $\frac{4 \times 16 \times 8}{24} = \frac{64}{3} = 21{\cdot}3'$ effective length.

And $\frac{916 \times 3 \times 7^2}{21{\cdot}3'} = \frac{916 \times 9 \times 49}{64} = \frac{229 \times 9 \times 49}{16}$

$= \frac{100989}{16} = 6312$ *lbs.* $=$ *Ans.*

Again, when a beam is fixed at one end, and loaded at the other, it will only bear $\frac{1}{4}$ of the weight as when supported at both ends, and loaded in the middle.

EXAMPLE 3.—What is the weight requisite to break a deal beam, 6 inches broad, 9 inches deep, and projecting 12 feet from the wall?

Here $\frac{566 \times 6 \times 9^2}{12 \times 4} = 283 \times 20\frac{1}{4} = 5730\frac{3}{4}$ *lbs.* $=$ *Ans.*

The same rules apply as well to beams of a cylindrical form, with this exception, that the strength of a round bar (as in the table) is multiplied by the cube of the diameter, in place of the breadth and square of the depth.

EXAMPLE 4.—Required the ultimate transverse strength of a solid cylinder of cast iron, 12 feet long and 5 inches diameter.

$$\text{Here } \frac{2026 \times 5^3}{12} = \frac{253250}{12} = 21104 \textit{ lbs.} = \textit{Ans.}$$

EXAMPLE 5.—What is the ultimate transverse strength of a hollow shaft of cast iron, 12 feet long, 8 inches diameter outside, and containing the same cross sectional area as a solid cylinder 5 inches diameter?

$$\text{Here } \frac{\{8^3 - \sqrt{(8^2-5^2)^3}\} \times 2026}{12} = \frac{(512 - \sqrt{39^3}) \times 2026}{12}$$

$$= \frac{(512 - \sqrt{59319}) \times 2026}{12} = \frac{(512 - 243{\cdot}555) \times 1013}{6}$$

$$= \frac{268{\cdot}445 \times 1013}{6} = \frac{271934{\cdot}785}{6} = 45322 \textit{ lbs.} =$$

Ans.

NOTE.—When a beam is fixed at both ends and loaded in the middle, it will bear one-half more than it will when loose at both ends.

And if a beam is loose at both ends, and the weight laid uniformly along its length, it will bear double; but if fixed at both ends, and the weight laid uniformly along its length, it will bear triple the weight.

PROBLEM II.

To find the breadth or depth of beams intended to support a permanent weight.

RULE.—Multiply the length between the supports, in feet, by the weight to be supported in *lbs.*, and divide the product by one-third of the ultimate strength of an inch bar (*as in the table*), multiplied by the square of the depth; the quotient will be the breadth, or, multiplied by the breadth, the quotient will be the square of the depth, both in inches.

EXAMPLE 1.—Required the breadth of a cast iron beam, 16 feet long, 7 inches deep, to support a weight of 4 tons in the middle.

Here 4 tons = 8960 *lbs.*

Then $\frac{8960 \times 16}{860 \times 7^2} = \frac{1024}{301} = 3{\cdot}4$ inches. = *Ans.*

EXAMPLE 2.—What must be the depth of a cast iron beam, 3·4 inches broad, 16 feet long, to bear a permanent weight of 4 tons in the middle?

Here $\sqrt{\frac{8960 \times 16}{860 \times 3{\cdot}4}} = 4 \times \sqrt{\frac{8960}{86 \times 34}} = 4 \times \sqrt{\frac{2240}{43 \times 17}} = 4 \times \sqrt{\frac{2240}{731}} = 4 \times \sqrt{3{\cdot}07} = 4 \times 1{\cdot}75 = 7$ inches. = *Ans.*

NOTE 1.—When a beam is fixed at both ends, the divisor must be multiplied by 1·5, on account of its being capable of bearing one-half more.

2.—When a beam is loaded uniformly throughout, and loose at both ends, the divisor must be multiplied by 2, because it will bear double the weight.

3.—If a beam is fast at both ends, and loaded uniformly throughout, the divisor must be multiplied by 3, on account that it will bear triple the weight.

EXAMPLE 3.—Required the breadth of an oak beam, 20 feet long, 12 inches deep, made fast at both ends, to be capable of supporting a weight of 12 tons in the middle.

Here 12 tons = 26880 *lbs.*

Then $\frac{26880 \times 20}{266{\cdot}6' \times 12^2 \times 1{\cdot}5} = \frac{2688 \times 6 \times 2}{8 \times 144 \times 3} = \frac{28}{3} =$ $9\frac{1}{3}$ inches. = *Ans.*

Again, when a beam is fixed at one end, and loaded at the other, the dividend must be multiplied by 4; because it will only bear one-fourth of the weight.

EXAMPLE 4.—Required the depth of a beam of ash, 6 inches broad, 9 feet projecting from the wall, to carry a weight of 47 *cwt.*

Here 47 *cwt.* = 5264 *lbs.*

Then $\sqrt{\frac{5264 \times 9 \times 4}{379 \times 6}} = \sqrt{\frac{329 \times 4^2 \times 3^2 \times 2^2}{2274}}$

$= 24 \times \sqrt{\frac{329}{2274}} = 24 \times \sqrt{\cdot 1447} = 24 \times \cdot 38 =$ 9·12 inches deep. = *Ans.*

And when the weight is not placed in the middle of a beam, the effective length must be found as in *Problem I.*

EXAMPLE 5.—Required the depth of a deal beam 20 feet long, to support a weight of 63 *cwt.* 6 feet from one end.

Here $\frac{4 \times 14 \times 6}{20} = \frac{84}{5} = 16 \cdot 8$, effective length of beam,

And 63 *cwt.* = 7056 *lbs.*

Hence $\sqrt{\frac{7056 \times 16 \cdot 8}{189 \times 6}} = \sqrt{\frac{784 \times 2}{15}} = \frac{28}{15} \times$

$\sqrt{30} = \frac{28}{15} \times 5 \cdot 477 = 10 \cdot 22$ inches deep. = *Ans.*

Beams or shafts exposed to lateral pressure are subject to all the foregoing rules; but in the case of water-wheel shafts, &c., some allowance must be made for wear, then the divisor may be changed from 675 to 600 for cast iron.

EXAMPLE 6.—Required the diameter of bearings for a water-wheel shaft 12 feet long, to carry a weight of 10 tons in the middle.

Here 10 tons = 22400 *lbs.*

Then $\sqrt[3]{\frac{12 \times 22400}{600}} = \sqrt[3]{448} = 7{\cdot}65$ inches diameter. = *Ans.*

And when the weight is equally distributed along its length, the cube root of half the quotient will be the diameter, thus:

Here $\sqrt[3]{\frac{448}{2}} = \sqrt[3]{224} = 6{\cdot}07$ inches diameter. = *Ans.*

EXAMPLE 7.—Required the diameter of a solid cylinder of cast iron, for the shaft of a crane, to be capable of sustaining a weight of 10 tons; one end of the shaft to be made fast in the ground, the other to project $6\frac{1}{2}$ feet; and the effective leverage of the jib as $1\frac{3}{4}$ to 1.

Here 10 tons = 22400 *lbs.*

Then $\frac{22400 \times 6{\cdot}5 \times 1{\cdot}75}{675 \times {\cdot}25} = \frac{2 \times 224 \times 13 \times 7}{27}$ = 1510.

And $\sqrt[3]{1510} = 11{\cdot}47$ inches diameter. = *Ans.*

The strength of cast iron to wrought iron, in this direction, is as 9 is to 14 nearly; hence, if wrought iron is taken in place of cast iron in the last example, what must be its diameter?

$\sqrt[3]{\frac{1510 \times 9}{14}} = \sqrt[3]{970{\cdot}7} = 9{\cdot}9$ inches diameter. = *Ans.*

ON TORSION OR TWISTING.

The strength of bodies to resist *torsion*, or wrenching asunder, is directly as the cubes of their diameters; or, if square, as the cube of one side; and inversely as the force applied multiplied into the length of the lever.

Hence the rule.—1. Multiply the strength of an inch bar, by experiment (*as in the following table*), by the

cube of the diameter, or of one side in inches; and divide by the radius of the wheel, or length of the lever also in inches; and the quotient will be the ultimate strength of the shaft or bar in *lbs.* avoirdupois.

2.—Multiply the force applied in pounds by the length of the lever in inches, and divide the product by one-third of the ultimate strength of an inch bar (*as in the table*), and the cube root of the quotient will be the diameter, or side of a square bar in inches; that is, capable of resisting that force permanently.

The following Table contains the result of experiments on inch bars, of various metals, in lbs. avoirdupois.

Names of Bodies.	*Round Bar.*	*One Third.*	*Square Bar.*	*One Third.*
Cast iron	11943	3981	15206	5069
English wrought iron	12063	4021	15360	5120
Swedish ditto	11400	3800	14592	4864
Blistered steel	20025	6675	25497	8499
Shear ditto	20508	6836	26112	8704
Cast ditto	21111	7037	26880	8960
Yellow brass	5549	1850	7065	2355
Cast copper	4825	1608	6144	2048
Tin	1688	563	2150	717
Lead	1206	402	1536	512

EXAMPLE 1.—What weight, applied on the end of a 5 feet lever, will wrench asunder a 3 inch round bar of cast iron?

Here $\frac{11943 \times 3^3}{60} = \frac{107487}{20} = 5374$ *lbs.* avoirdupois. $=$ *Ans.*

EXAMPLE 2.—Required the side of a square bar of wrought iron, capable of resisting the twist of 600 *lbs.* on the end of a lever 8 feet long.

$$\sqrt[3]{\frac{600 \times 96}{5120}} = \sqrt[3]{\frac{15 \times 3}{4}} = \sqrt[3]{\frac{90}{8}} = \frac{\sqrt[3]{90}}{2} =$$

$2\frac{1}{4}$ inches. $=$ *Ans.*

In the case of revolving shafts for machinery, &c. the strength is directly as the cubes of their diameters and revolutions, and inversely as the resistance they have to overcome; hence,

From *practice*, we find that a 40-horse power steam-engine, making 25 revolutions per minute, requires a shaft (*if made of wrought iron*) to be 8 inches diameter: now, the cube of 8, multiplied by 25, and divided by 40 = 320; which serves as a constant multiplier for all others in the same proportion.

EXAMPLE 3.—What must be the diameter of a wrought iron shaft for an engine of 65-horse power, making 23 revolutions per minute?

Here $\sqrt[3]{\frac{65 \times 320}{23}} = \sqrt[3]{\frac{20800}{23}} = \sqrt[3]{904{\cdot}4} = 9{\cdot}67$ inches diameter. = *Ans.*

Mr. Robertson Buchanan, in his Essay on Shafts, gives 400 as a constant multiplier for cast iron shafts that are intended for first movers in machinery;

200 for second movers; and
100 for shafts connecting smaller machinery, &c.

EXAMPLE 1.—The velocity of a 30-horse power steam-engine is intended to be 19 revolutions per minute. Required the diameter of bearings for the fly wheel shaft.

Here $\sqrt[3]{\frac{400 \times 30}{19}} = \sqrt[3]{\frac{12000}{19}} = \sqrt[3]{631{\cdot}6} = 8{\cdot}58$ inches diameter. = *Ans.*

EXAMPLE 2.—Required the diameter of the bearings of shafts, as second movers for a 30-horse engine; their velocity being 36 revolutions per minute.

Here $\sqrt[3]{\frac{200 \times 30}{36}} = \sqrt[3]{\frac{1000}{6}} = 10 \times \sqrt[3]{\frac{1}{6}} =$

$$\frac{10}{6}\sqrt[3]{36} = \frac{10}{6} \times 3{\cdot}3 = 5{\cdot}5 \text{ inches diameter.} = \textit{Ans.}$$

NOTE.—When shafting is intended to be of wrought iron, use 160 as the multiplier for second movers; and 80 for shafts connecting smaller machinery.

TABLE

Of the proportionate length of bearings, or journals for shafts of various diameters.

Diameter in Inches.	*Length in Inches.*	*Diameter in Inches.*	*Length in Inches.*
1	1¾	6½	8¾
1½	2¼	7	9⅜
2	3	7½	10
2¼	3¼	8	10¾
2½	3½	8½	11⅜
3	4¼	9	12
3½	4⅞	9½	12¾
4	5½	10	13¼
4½	6⅛	10½	14
5	6¾	11	14½
5½	7½	11½	15¼
6	8¼	12	16

OF THE MECHANICAL POWERS.

When power is applied to overcome weight, or force to overcome resistance, the machines employed are called mechanic powers; and the application of such, the science of mechanics.

The power and weight are said to balance each other, or to be in equilibrio, when the effort of the one to produce motion in one direction is equal to the effort of the other to produce it in an opposite direction; or when the weight opposes that degree of resistance which is precisely required to destroy the action of the power.

The momentum or quantity of force of any moving body is the result of the quantity of matter multiplied by the velocity with which it is moved; and when the products arising from the multiplication of the particular quantities of matter in any two bodies by their respective velocities are equal, their momentums will be so too.

And it holds universally true, that when two bodies are suspended upon any machine, so as to act contrary to each other, if the machine be put in motion, and the perpendicular ascent of one body, multiplied into its weight, be equal to the perpendicular descent of the other multiplied into its weight, those bodies, however unequal they may be in weight, will balance each other in all situations; for, as the whole ascent of the one is performed in the same time as the whole descent of the other, their respective velocities must be as the spaces they move through; and the excess of weight in the one is compensated by the excess of velocity in the other. Upon this principle it is easy to compute the power of any machine, either simple or compound; for it is only finding how much swifter the power moves than the weight, and just so much is the power increased by the help of the machine.

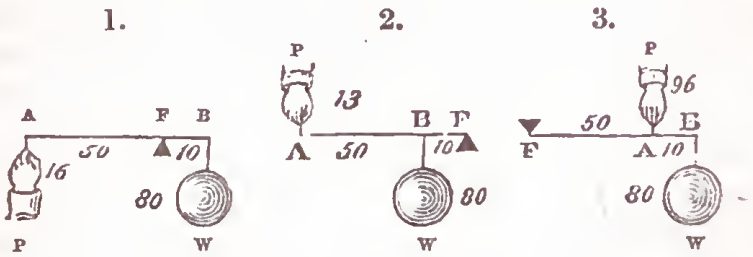
The simple machines, usually called mechanic powers, are six in number, namely, the Lever, the Wheel and Axle, the Pulley, the Inclined Plane, the Wedge, and the Screw.

There are three kinds of levers, caused by the different situations of the weights, props, and powers.

1.—When the weight is at one end, the power at the other, and the prop somewhere between.

2.—When the prop is at one end, the power at the other, and the weight between. And,

3.—When the prop is at one end, the weight at the other, and the power between. Thus,



That on any kind of lever there may be a balance between the power and weight, their intensities must be inversely as their distances from the fulcrum, or prop, at which they act, that is, $P \times A F = W \times B F$; therefore,

Multiply the weight or power given by its distance from the prop, and divide by the distance of the prop from the power or weight; the quotient will be the power or weight required.

Examples 1, 2, and 3.

Required the power necessary to counterpoise a weight of 80 *lbs.* on each of the three levers, whose lengths are 60 inches, and in the first and second 10 inches from weight to prop, the third being 10 inches from weight to power.

First .... $\frac{80 \times 10}{50} = 16$ *lbs.* power. = 1*st Ans.*

Second.. $\frac{80 \times 10}{60} = 13{\cdot}33$ *lbs.* power. = 2*nd Ans.*

Third... $\frac{80 \times 60}{50} = 96$ *lbs.* power. = 3*rd Ans.*

EXAMPLE 4.—What power is necessary to raise a weight of 620 *lbs.* by a lever of the first order, 72 inches long, and the prop placed 12 inches from the weight?

Here $72 - 12 = 60$ inches, the distance of prop to power.

Then $\frac{620 \times 12}{60} = 124$ *lbs.* = *Ans.*

NOTE.—In a lever of the first kind, when its length is given together with the weight and power, multiply the weight or power by the length of the lever, and divide by the sum of the weight and power, the quotient is the distance of the power or weight from the prop.

EXAMPLE 5.—A weight of 620 *lbs.* is to be lifted by a power of 124 *lbs.* applied to the end of a lever of the first order, 72 inches long; required at what distance from the weight the prop must be placed.

Here $\frac{124 \times 72}{620 + 124} = \frac{124 \times 72}{744} = 12$ inches. = *Ans.*

EXAMPLE 6.—A beam 20 feet long, and supported at both ends, bears a weight of 73 *cwt.* 4 feet 6 inches from one end; required the proportion of weight upon each support.

Here $\frac{\text{whole weight} \times \text{dist. from nearest support}}{\text{whole length}} =$

$\frac{73 \times 4{\cdot}5}{20} = 16{\cdot}425$ *cwt.* on the furthest support. = 1*st Ans.*

And $73 - 16{\cdot}425 = 56{\cdot}575$ *cwt.* on the nearest support. = 2*nd Ans.*

EXAMPLE 7.—A weight of 300 *lbs.* is fixed on the end of a lever 6 feet long; required the power, applied $2\frac{1}{2}$ feet from the prop, to raise the weight.

Here $\frac{300 \times 6}{2{\cdot}5} = 720$ *lbs.* power. = *Ans.*

WHEEL AND AXLE.

Here the velocity of the power is to the velocity of the weight as the diameter of the wheel is to the diameter of the axle; hence, divide the velocity of the power by the velocity of the weight, and the quotient is the weight that the power is equal to.

EXAMPLE 1.—A power equal to 30 *lbs.* is applied to the winch of a crane whose length is 15 inches; the pinion contains 10 teeth, the wheel 120, and the barrel is 9 inches diameter; required the weight raised.

Here $15 \times 2 = 30$, the diameter of the circle described by the winch, or handle.

Next $120 \div 10 = 12$ revolutions of the pinion for one of the wheel.

Then $\frac{30 \times 12 \times 30}{9} = 1200$ *lbs.* raised by this crane. = *Ans.*

EXAMPLE 2.—What would be the increase of power, in the last example, if a wheel of 150 teeth, and a pinion of 15, were added to the crane?

Here $150 \div 15 = 10$, that is, the velocity of the weight is diminished, while the velocity of the power is the same.

Then $\frac{30 \times 12 \times 10 \times 30}{9} = 12000$ *lbs.* raised = *Ans.*, the power here being increased ten times.

EXAMPLE 3.—What power is requisite to raise 42 tons 60 feet high in 10 minutes, the velocity of the power being 20 feet per minute?

Here $60 \div 10 = 6$, and $\frac{42 \times 6}{20} = 12{\cdot}6$ tons power. = *Ans.*

TO CALCULATE FOR THE DIFFERENT PARTS OF A CRANE, AS RESPECTS MECHANICAL ADVANTAGE.

1.—*The number of revolutions of the pinion to one of the wheel, the length of the handle, and the force applied given, to find the diameter of the barrel.*

RULE.—Multiply the diameter of the circle described by the winch, or handle, in inches, by the power applied in *lbs.*, and by the number of revolutions of the pinion to one of the wheel; divide the product by the weight to be raised in *lbs.*, and the quotient is the barrel's diameter in inches.

EXAMPLE.—Suppose that two men were required to raise a weight of one ton by a crane, and each man to exert a constant force of $33\frac{1}{2}$ *lbs.* on a handle 16 inches long, the pinion making seven revolutions for one of the wheel, what must be the barrel's diameter?

Here $16 \times 2 = 32$ inches, diameter of the circle described by the handle, and $33\frac{1}{2} \times 2 = 67$ *lbs.* constant force.

Then $\frac{32 \times 67 \times 7}{2240} = 6{\cdot}7$ inches. = *Ans.*

2.—*The diameter of the barrel, the length of the handle, and force applied given, to find the number of revolutions of the pinion to one of the wheel.*

RULE.—Multiply the weight to be raised in *lbs.* by the diameter of the barrel in inches, and divide the product by the diameter of the circle described by the handle in inches, multiplied by the power applied in *lbs.*, and the quotient is the revolutions of the pinion to one of the wheel.

EXAMPLE.—What must be the number of revolutions of the pinion to one of the wheel, when the power applied is 67 *lbs.*, the length of the handle 16 inches,

and the barrel 6·7 inches diameter, to counterpoise a weight of one ton, or 2240 *lbs.?*

Here $\frac{2240 \times 6{\cdot}7}{32 \times 67} = 7$ revolutions to one of the wheel. = *Ans.*

3.—*The diameter of the barrel, the number of revolutions of the pinion to one of the wheel, and the power applied given, to find the length of the handles.*

Rule.—Multiply the weight to be raised in *lbs.* by the barrel's diameter in inches, and divide the product by the power applied in *lbs.*, multiplied by the number of revolutions of the pinion to one of the wheel, and half the quotient is the length of the handles.

Example.—It is estimated that the united effort of two men at the handles of a crane is 67 *lbs.* nearly; now a crane having a barrel of 6·7 inches diameter, and a pinion 7 to 1 of the wheel, what must be the length of handles to raise a weight of 1 ton?

Here $\frac{2240 \times 6{\cdot}7}{67 \times 7 \times 2} = \frac{32}{2} = 16$ inches. = *Ans*

4.—*The diameter of the barrel, the revolutions of the pinion to one of the wheel, and length of handles given, to find the power required.*

Rule.—Multiply the weight to be raised in *lbs.* by the diameter of the barrel in inches, and divide the product by the diameter of the circle described by the handle, multiplied by the revolutions of the pinion to one of the wheel, and the quotient is the power required.

Example.—What power will be required to raise one ton by a crane, whose barrel is 6·7 inches diameter, the pinion 7 to 1 of the wheel, and each handle 16 inches long?

Here $\frac{2240 \times 6{\cdot}7}{32 \times 7} = 67$ *lbs.* power. = *Ans.*

NOTE.—The handles of a crane ought not to be less than 2 feet 11 inches, or 3 feet from the ground, and the jib to stand at an angle of about 45 degrees.

To find the thickness of cast iron for a crane post, when fixed at one end, and loaded at the other.

RULE.—Multiply the weight that the crane is to lift in *lbs.* by the leverage of the jib to one of the post, and by the length of the post in feet; divide the product by 168, then subtract the quotient from the cube of the outside diameter, and the cube root of the difference is the inside diameter.

EXAMPLE.—What thickness must the metal be for a crane post to carry a weight of 10 tons, the diameter of the post being 16 inches, and projecting 6 feet from the ground, the leverage of the jib being as $3\frac{1}{2}$ to 1 of the post?

Here 10 tons = 22400 *lbs.*

Then $\sqrt[3]{\left(16^3 - \frac{22400 \times 3{\cdot}5 \times 6}{168}\right)} = \sqrt[3]{}$ (4098 − 2800) = $\sqrt[3]{}$ 1298 = 10·9 the inside diameter.

And $\frac{16-10{\cdot}9}{2} = \frac{5{\cdot}1}{2} = 2{\cdot}6$ inches in thickness. = *Ans.*

THE PULLEY.

A single pulley, that only turns on its axis, and does not move out of its place, serves only to change the direction of the power, but gives no mechanical advantage. The advantage gained is always as twice the number of moveable pulleys, without taking any notice of the fixed pulleys necessary to compose the system of pulleys; hence, divide the weight to be raised by twice the number of moveable pulleys, and the quotient is the power required to raise the weight, in terms of the same name.

EXAMPLE 1.—What power is requisite to raise 250 *lbs.* with a pair of four-shieved blocks, the one block moveable and the other fixed?

Here $\frac{250}{4 \times 2} = \frac{125}{4} = 31{\cdot}25$ *lbs.* power. = *Ans.*

EXAMPLE 2.—What weight will a power of 120 *lbs.* raise, when applied to a three and four-shieved block, the three being moveable and the other fixed?

Here $3 \times 2 \times 120 = 720$ *lbs.* raised. = *Ans.*

THE INCLINED PLANE.

In the inclined plane, when the power acts parallel thereto, the weight it will support is to the power applied as the length of the plane to its perpendicular height; hence, multiply the weight by the perpendicular height of the plane, and divide by its length, the quotient is the power that will support that weight upon the plane.

EXAMPLE 1.—Required the power, or equivalent weight, capable of supporting a load of 300 *lbs.* upon an inclined plane 50 feet long and 16 feet high.

Here 50 is to 16 as 300 *lbs.* is to 96 *lbs.*, the power. = *Ans.*

Or, $\frac{300 \text{ lbs.} \times 16}{50} = 96$ *lbs.* the power. = *Ans.* *as before.*

EXAMPLE 2.—A power of 120 *lbs.*, with a velocity of 50 feet per minute, is to be applied to move a weight up an inclined plane at the rate of 30 feet per minute; the plane is 25 feet long and 8 feet high; required the weight that the power is equal to.

Here $\frac{30 \times 8}{25} = \frac{48}{5}$ = perpendicular velocity of the weight.

Then, as $\frac{48}{5} : 50 :: 120$ *lbs.* : 625 *lbs.* = *Ans.*

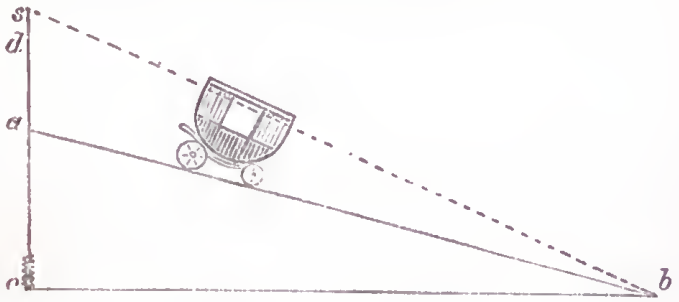
The weight multiplied by the length of the base, and divided by the length of the plane, equals the pressure on the plane.

The space which a body describes upon an inclined plane, when descending by the force of gravity, is to the space which it would fall freely in the same time, as the height is to the length of the plane, and the spaces being the same, the times will be inversely in this proportion.

Again, if two bodies descend from rest down two planes, equally inclined to the horizon, and then, without any loss of velocity, proceed to descend down two other inclined planes, also equally inclined to the horizon, the lengths of which are to each other in the same proportion as the lengths of the first two planes, the squares of the times of their whole motion will be in the same proportion as the lengths of the planes.

Means of ascertaining practically the effect produced by inclined planes.

Provide a board or box, *a b*, capable of holding pebbles, sand, &c., and which, by a screw, *c*, can be easily raised at one end, as *a d s*, &c.



When *a b* lies flat on *c b*, a carriage placed upon *a b* will be at rest; but by the screw at *c* raising *a b* leisurely, the carriage will, at a certain height, set off by itself, and run down the plane. Then are we in possession of a triangle that solves what force is necessary to drag any load of any kind on a road or level ground; for the

hypotenuse *a b* represents the weight of the carriage, and the perpendicular *a c* what portion of that weight is necessary to draw the carriage on level ground; thus,

Suppose the carriage . . 12 *cwt.*
The line *a b* . . . . . 24 *feet.*
Height *c a* . . . . . 3 *feet.*

The declivity, then, is as 3 to 24, or $\frac{1}{8}$. In this case it will be found that $\frac{1}{8}$ of the weight of the carriage would drag it on such a road or level ground, namely, $1\frac{1}{2}$ *cwt.*; but if the road were very deep and rough, it might require to be raised perhaps as high as *d* or *s*, before the carriage would set off. Now, if *c s* were half the length of *s b*, then it would require one-half the weight of the carriage to drag it on level ground, or, in the above case, 6 *cwt.*

This rule is universal, and has been proved by carriages at large, on roads of every description.

In estimating the draft up hill, the draft on the level must be added to it. Suppose the hill rises 1 foot in 4, then $\frac{1}{4}$ part of the weight must be added to the draft on level ground.

If the weight be, as before, 12 *cwt.*, then $\frac{1}{4}$ would be 3 *cwt.*; and if its draft on a level were $1\frac{1}{2}$ *cwt.*, then $4\frac{1}{2}$ *cwt.* would be the real draft necessary to draw 12 *cwt.* up a hill rising 1 foot in 4, &c.

Example.—Suppose I find that, on an edge railway, a loaded carriage will just move by itself when there is a descent of $3\frac{1}{2}$ inches per chain, or about one perpendicular for 224 horizontal, which is (reckoning the carriage to weigh 1 ton) 10 *lbs.* $= \frac{1\ ton}{224}$ required to move it on a level. Now, from the above data, what force will be required to drag the same weight up a similar road ascending 1 inch per yard, or $\frac{1}{36}$? Here $\frac{1}{36}$ of a ton is 62·2 *lbs.*, which added to 10 *lbs.* as above, amounts to 72·2 *lbs.*, the weight required to drag it up an ascent of $\frac{1}{36}$; and allowing the strength of an ordinary horse

to be 140 *lbs.*, he will only be able to drag 1·9, or say 2 tons up an ascending plane of 1 in 36.

THE WEDGE.

As the wedge is seldom used without being driven, the force of the blow is not easily ascertained; of course, in practice it is not worth taking into account with respect to calculation.

THE SCREW.

The advantage gained by the screw amounts to this, that the circumference of the circle described by the lever or handle is to the pitch of the screw (*viz.* the distance between two consecutive threads) as the weight to the power.

EXAMPLE.—What power is necessary to raise a weight of 6000 *lbs.*, the length of the lever being 20 inches and the screw $\frac{3}{4}$ pitch?

Here as $20 \times 2 \times 3{\cdot}1416 = 125{\cdot}7 : {\cdot}75 :: 6000$ *lbs.* : 35·8 *lbs.* power required.

NOTE.—There are few machines but what, on account of the friction of the parts against one another, will require a third part more power to work them, when loaded, than is requisite to constitute a balance between power and weight.

The following Table shows the estimated power of man or horse as applied to machinery.

Application of the Power.	Lbs. Avr. at the rate of 220 feet per minute.	Or Lbs. Avr. at the rate of one foot per minute.
A man is supposed to be capable of lifting or carrying	27·273	or 6000
A man is supposed to be capable of turning the winch of a crane with a force equal to	28·636	or 6300
When the united efforts of two men are applied to the winch of a crane, the handles being at right angles, each man exerts a force equal to.....	33·409	or 7350
A man is supposed to exert a power in pumping equal to.....	17·336	or 3814
In ringing, a man exerts a force equal to.....	38·955	or 8570
And in rowing	40·955	or 9010
The power of a horse equal to	150	or 33000

OF FALLING BODIES.

In bodies falling freely by their own weight, their velocities are as the times, and the spaces as the square of the times; therefore, if the times be as the numbers ..... 1, 2, 3, 4, &c.
The velocities will be also ..... 1, 2, 3, 4, &c.
The spaces passed through..... 1, 4, 9, 16, &c.
And the spaces for each time, as the odd numbers ..... 1, 3, 5, 7, &c.

It has been ascertained by experiment that a body falling freely from rest will descend through $16\frac{1}{10}$ feet in the first second of time, and will then have acquired a velocity which, being continued uniformly, will carry it through $32\frac{1}{5}$ feet in the next second; consequently, if the first series of numbers be expressed in seconds, 1″ 2″ 3″

Velocities in feet will be.....	$32\frac{1}{5}$	$64\frac{2}{5}$	$96\frac{3}{5}$,	&c.
Spaces in the whole times	$16\frac{1}{10}$	$64\frac{2}{5}$	$144\frac{9}{10}$,	&c.
And the spaces for each second	$16\frac{1}{10}$	$48\frac{3}{10}$	$80\frac{1}{2}$,	&c.

To find the velocity a falling body will acquire in any given time.

RULE.—Multiply the time in seconds by 32·19, and the product will be the velocity acquired in feet per second.

EXAMPLE.—Required the velocity in 7 seconds.

Here $32{\cdot}19 \times 7 = 225{\cdot}33$ feet, velocity acquired. = *Ans.*

To find the velocity a body will acquire by falling from any given height.

RULE.—Multiply the space in feet by 64·4, and the square root of the product will be the velocity acquired in feet per second.

EXAMPLE.—Required the velocity a ball will acquire in descending through 201 feet.

Here $\sqrt{(64{\cdot}4 \times 201)} = \sqrt{12944{\cdot}4} = 113{\cdot}8$ feet. = *Ans.*

To find the space through which a body will fall in any given time.

RULE.—Multiply the square of the time in seconds by 16·095, and the product will be the space in feet.

EXAMPLE.—Required the space fallen through in 7 seconds.

Here $16{\cdot}095 \times 7^2 = 16{\cdot}095 \times 49 = 788{\cdot}655$ feet. = *Ans.*

NOTE.—The velocity acquired by a body in falling from rest, through a given height, is the same whether it fall freely or descend through a plane any way inclined.

The diameter of a circle perpendicular to the horizon, and any chord terminating at either extremity of that diameter, are described by a falling body in the same length of time.

And the velocities which bodies acquire by descending along chords of the same circle, are as the lengths of those chords.

TABLE

Of accelerated motion of falling bodies.

Time in seconds of the body's fall.	Space fallen through during each second in feet.	Whole space fallen through in feet.	Velocity acquired at the end of the time.
1	16·095	16 095	32·19
2	48·286	64·381	64·38
3	80·476	144·857	96·57
4	112·667	257·524	128·76
5	144·857	402·381	160·95
6	177·048	579·429	193·14
7	209·238	788·668	225·33
8	241·429	1030·097	257·52
9	273·619	1303·716	289·71
10	305·810	1609·526	321·91

ON PENDULUMS.

The length of a pendulum that vibrates seconds, or 60, in the latitude of Königsberg (54° 42′ 50″ N.) is, according to Bessel, 440·8179 lines of his toise, which is shorter by $\frac{1}{1\,2\,7\,8}$ of a line than the toise of Peru.

The French metre = ·513074 of the toise of Peru = 39·370089 English inches, with which we get the length of the second's pendulum at Königsberg = 39·14997 English inches, and at London (Lat. 51° 31′ 8·4″ N.) = 39·13907 English inches; and $\surd$ 39·1391 × 60 = 375·367, serves as a constant number for other pendulums; thus, 375·367, divided by the square root of the pendulum's length, gives the number of vibrations per minute; and divided by the vibrations per minute, gives the square root of the length of the pendulum.

EXAMPLE 1.—Required the number of vibrations a pendulum 25 inches long will make per minute.

Here $\frac{375{\cdot}367}{\surd 25} = \frac{375{\cdot}367}{5} = 75{\cdot}073$ vibrations per minute. = *Ans.*

EXAMPLE 2.—Required the length of a pendulum to make 80 vibrations per minute.

Here $\left(\frac{375{\cdot}367}{80}\right)^2 = 4{\cdot}6921^2 = 22{\cdot}0157$ inches long. = *Ans.*

Table containing the length of pendulums, in English inches, to vibrate seconds in various parts of the world. From the Ency. Metrop., Art. "Figure of the Earth," by G. B. Airy, Esq., Astronomer Royal.

At Sierra Leone..	39·01997 *in.*	At New York	39·10120 *in.*
„ Trinidad.....	39·01888 „	„ Bordeaux.....	39·11296 „
„ Madras	39·02630 „	„ Paris	39·12877 „
„ Jamaica.....	39·03503 „	„ Leith Fort....	39·15546 „
„ Rio Janeiro....	39·04350 „	„ Greenland	39·20335 „

A pendulum vibrating half seconds in the latitude of London is 9·8 inches in length; and for quarter seconds, 2·5 inches.

ON THE VELOCITY OF WHEELS, DRUMS, PULLEYS, &c.

When wheels are applied to communicate motion from one part of a machine to another, their teeth act alternately on each other; consequently, if one wheel contains 60 teeth and another 20, the one containing 20 teeth will make three revolutions, while the other makes but one; and if drums or pulleys are taken in place of wheels, the result will be the same; because their circumferences, describing equal spaces, render their revolutions unequal: from this the rule is derived, namely,

Multiply the velocity of the driver by the number of teeth it contains, and divide by the velocity of the driven; the quotient will be the number of teeth it ought to contain. *Or*, multiply the velocity of the driver by its diameter, and divide by the velocity of the driven; the quotient will be the diameter of the driven.

If the velocities of driver and driven are given with the distance of their centres,

Then the sum of the velocities : $\left\{\begin{array}{l}\text{velocity of driver}\\ \text{velocity of driven}\end{array}\right\}$ ::

distance of centres : $\left\{\begin{array}{l}\text{radius of driven.}\\ \text{radius of driver.}\end{array}\right.$

Example 1.—If a wheel that contains 75 teeth makes 16 revolutions per minute, required the number of teeth in another to work in it, and make 24 revolutions in the same time.

$$\text{Here } \frac{75 \times 16}{24} = 50 \text{ teeth.} = \textit{Ans.}$$

Example 2.—A wheel, 64 inches diameter, and making 42 revolutions per minute, is to give motion to a shaft at the rate of 77 revolutions in the same time:

required the diameter of a wheel suitable for that purpose.

$$\text{Here } \frac{64 \times 42}{77} = 34{\cdot}9 \text{ inches.} = \textit{Ans.}$$

EXAMPLE 3.—Required the number of revolutions per minute made by a wheel or pulley 20 inches diameter, when driven by another of 4 feet diameter, and making 46 revolutions per minute.

$$\text{Here } \frac{48 \times 46}{20} = 110{\cdot}4 \text{ revolutions.} = \textit{Ans.}$$

EXAMPLE 4.—A shaft, at the rate of 22 revolutions per minute, is to give motion, by a pair of wheels, to another shaft at the rate of $15\frac{1}{2}$; the distance of the shafts from centre to centre is $45\frac{1}{2}$ inches; the diameters of the wheels at the pitch lines are required.

$$\text{Here } 22+15{\cdot}5 : 22 :: 45{\cdot}5\,\textit{in.} : \frac{22 \times 45{\cdot}5}{22+15{\cdot}5} = 26{\cdot}69\,\textit{in.}$$

the radius of the driven wheel; which, doubled, gives 53·38 *in.*, the diameter. = 1*st Ans.*

Therefore 45·5 *in.* − 26·69 *in.* = 18·81 *in.*, the radius of the driver; which, doubled, gives 37·62 *in.*, the diameter. = 2*nd Ans.*

EXAMPLE 5.—Suppose a drum to make 20 revolutions per minute, required the diameter of another to make 58 revolutions in the same time.

Here $58 \div 20 = 2{\cdot}9$, that is, their diameters must be as 2·9 to 1; thus, if the one making 20 revolutions be called 30 inches, the other will be $30 \div 2{\cdot}9 = 10{\cdot}345$ inches diameter.

EXAMPLE 6.—Required the diameter of a pulley, to make $12\frac{1}{2}$ revolutions in the same time as one of 32 inches making 26.

$$\text{Here } \frac{32 \times 26}{12{\cdot}5} = 66{\cdot}56 \text{ inches diameter.}$$

EXAMPLE 7.—A shaft, at the rate of 16 revolutions per minute, is to give motion to a piece of machinery at the rate of 81 revolutions in the same time; the motion is to be communicated by means of two gearing wheels and two pulleys with an intermediate shaft; the driving wheel contains 54 teeth, and the driving pulley on the axis of the driven wheel is 25 inches diameter; required the number of teeth in the other wheel, and the diameter of the other pulley.

Let the driven wheel have a velocity of 36, a mean proportional between the extreme velocities 16 and 81;

then, $\frac{16 \times 54}{36} = 24$, the number of teeth in the driven wheel. = 1*st Ans.*

And $\frac{36 \times 25}{81} = 11{\cdot}11$ inches, diameter of the driven pulley. = 2*nd Ans.*

EXAMPLE 8.—Suppose in the last example the revolutions of one of the wheels to be given, the number of teeth in both, and likewise the diameter of each pulley, to find the revolutions of the last pulley.

Here $\frac{16 \times 54}{24} = 36$, velocity of the intermediate shaft. = *Ans.*

Also $\frac{36 \times 25}{11{\cdot}11} = 81$, the velocity of the machine.

TABLE

For finding the radius of a wheel when the pitch is given, or the pitch of a wheel when the radius is given, that shall contain from 10 *to* 150 *teeth, and any pitch required.*

Num. of Teeth.	Radius.	Num. of Teeth.	Radius.	Num. of Teeth.	Radius.	Num. of Teeth.	Radius.
10	1·618	46	7·327	81	12·893	116	18 464
11	1·775	47	7·486	82	13·051	117	18·623
12	1 932	48	7·645	83	13·210	118	18·782
13	2·089	49	7·804	84	13·370	119	18 941
14	2·247	50	7·963	85	13·531	120	19·101
15	2·405	51	8·122	86	13·691	121	19 260
16	2·563	52	8·281	87	13·849	122	19·419
17	2 721	53	8·440	88	14·008	123	19·578
18	2·879	54	8·599	89	14·168	124	19·737
19	3·038	55	8·758	90	14·327	125	19·896
20	3·196	56	8·917	91	14·486	126	20·055
21	3·355	57	9·076	92	14·645	127	20·214
22	3 513	58	9·235	93	14·804	128	20·374
23	3·672	59	9 395	94	14·963	129	20·533
24	3·831	60	9·554	95	15 122	130	20·692
25	3·989	61	9·713	96	15·281	131	20·851
26	4·148	62	9·872	97	15·440	132	21·010
27	4·307	63	10·031	98	15·600	133	21·169
28	4·466	64	10·190	99	15·759	134	21·328
29	4·625	65	10·349	100	15·918	135	21·488
30	4·783	66	10·508	101	16·077	136	21·647
31	4·942	67	10·667	102	16·236	137	21·806
32	5·101	68	10·826	103	16·395	138	21·965
33	5·260	69	10·985	104	16·554	139	22·124
34	5·419	70	11·144	105	16·713	140	22·283
35	5·578	71	11·303	106	16·873	141	22 442
36	5·737	72	11·463	107	17·032	142	22·602
37	5·896	73	11·622	108	17·191	143	22·761
38	6·055	74	11·781	109	17·350	144	22 920
39	6·214	75	11·940	110	17·509	145	23 079
40	6·373	76	12·099	111	17·668	146	23·238
41	6·532	77	12·258	112	17·827	147	23·397
42	6·691	78	12·417	113	17·987	148	23·556
43	6·850	79	12·576	114	18·146	149	23·716
44	7·009	80	12·735	115	18·305	150	23·875
45	7·168						

RULE.—Multiply the radius in the table by the pitch given, and the product will be the radius of the wheel required.

Or, divide the radius of the wheel by the radius in the table, and the quotient will be the pitch of the wheel required.

EXAMPLE 1.—Required the radius of a wheel to contain 64 teeth, of 3 inch pitch.

Here $10{\cdot}19 \times 3 = 30{\cdot}57$ inches. = *Ans.*

EXAMPLE 2.—What is the pitch of a wheel to contain 80 teeth, when the radius is 25·47 inches?

Here $25{\cdot}47 \div 12{\cdot}735 = 2$ inch pitch.

Or, set off upon a straight line seven times the pitch given, divide that, or another exactly the same length, into eleven equal parts; call each of those divisions four, or each of those divisions will be equal to four teeth upon the radius.

EXAMPLE.—Were it required to find the diameter of a wheel to contain 21 teeth, the construction would be as follows:—

1		2		3		4		5		6		7
1	2	3	4	5	6	7	8	9	10	11		

< . . 4 . . . 8 . . 12 . . . 16 . . 20 >

Thus, 5 divisions and $\frac{1}{4}$ of another equal the radius of the wheel.

Regular approved proportions for wheels with flat arms in the middle of the ring, and ribs, or feathers, on each side.

The length of the teeth = $\frac{6}{9}$ the pitch, besides clearance, or $\frac{5}{7}$ the pitch, clearance included.

Thickness of the teeth	$\frac{4}{9}$	the pitch.
Breadth on the face	$2\frac{1}{2}$	,,
Edge of the rim	$\frac{4}{9}$	,,
Rib projecting inside the rim	$\frac{4}{9}$	,,
Thickness of the flat arms	$\frac{4}{9}$	,,

Breadth of the arms at the points = 2 teeth and $\frac{1}{4}$ the pitch, getting broader towards the centre of the wheel in the proportion of $\frac{1}{2}$ inch to every foot in length.

Thickness of the ribs, or feathers, $\frac{1}{4}$ the pitch.

Thickness of metal round the eye, or centre, $\frac{7}{9}$ the pitch.

Wheels made with plain arms, the teeth are in the same proportion as above; the ring and the arms are each equal to one cog or tooth in thickness, and the metal round the eye same as above, in feathered wheels.

To find the power that a cast iron wheel is capable of transmitting at any given velocity.

RULE.—Multiply the breadth of the teeth, or face of the wheel in inches, by the square of the thickness of one tooth, and divide the product by the length of the teeth, the quotient is the strength in horses' power at a velocity of 136 feet per minute.

EXAMPLE.—Required the power that a wheel of the following dimensions ought to transmit with safety, namely,

Breadth of teeth.....	$7\frac{1}{2}$ inches.
Thickness	1·4 „
And length.....	2 „

Here $\frac{7{\cdot}5 \times 1{\cdot}4^2}{2} = \frac{7{\cdot}5 \times 1{\cdot}96}{2} = 7{\cdot}35$ horses' power.

The strength at any other velocity is found by multiplying the power so obtained by any other required velocity, and by ·0044, the product is the power at that velocity.

Suppose the wheel as above, at a velocity of 320 feet per minute.

Then $7{\cdot}35 \times 320 \times {\cdot}0044 = 10{\cdot}3488$ horses' power.

ON THE MAXIMUM VELOCITY AND POWER OF WATER WHEELS.

Since publishing the first edition of this work, I have endeavoured, as far as possible, to acquire the most improved practical principles of water wheels as a moving power; and

1.—*Of undershot wheels.*

The term "undershot" is applied to a wheel when the water strikes at, or below, the centre. And the greatest effect is produced when the periphery of the wheels moves with a velocity of ·57 that of the water; —then, to find the velocity of the water, multiply the square root or the perpendicular height of the fall in feet by 8, and the product is the velocity in feet per second.

EXAMPLE.—Required the maximum velocity of an undershot wheel, when propelled by a fall of water 6 feet in height.

Here $8 \surd 6 = 2{\cdot}45 \times 8 = 19{\cdot}6$ feet velocity of water.

And $19{\cdot}6 \times {\cdot}57 = 11{\cdot}17$ feet per second for the wheel. = *Ans.*

2.—*Of breast and overshot wheels.*

Wheels that have the water applied between the centre and the vertex are styled breast wheels, and overshot when the water is brought over the wheel and laid on the opposite side; however, in either case the maximum velocity is $\frac{2}{3}$ that of the water; then, to find the head of water proper for a wheel at any velocity, say,

As the square of 16·095, or 259, is to 4, so is the

square of the velocity of the water in feet per second, to the head * of water required.

EXAMPLE.—Required the head of water necessary for a wheel of 24 feet diameter, moving with a velocity of 5 feet per second.

Here $5 \div \frac{2}{3} = 5 \times \frac{3}{2} = 7{\cdot}5$, velocity of the water in feet.

And $259 : 4 :: 7{\cdot}5^2 : {\cdot}87$ feet, head of water required. = *Ans.*

But for wheels of from 15 to 20 feet diameter inclusive, add one-tenth of the diameter minus 1 foot. And for wheels of from 20 to 30 feet diameter inclusive, add one-twentieth of the diameter.

This additional head is intended to compensate for the friction of water in the aperture of the sluice to keep the velocity as 3 to 2 of the wheel; thus, in place of ·87 feet head for a 24 feet wheel, it will be $·87 + \frac{24}{20} = ·87 + 1{\cdot}2 = 2{\cdot}07$ feet head of water.

If the water flow from under the sluice, multiply the square root of the depth in feet by 5·4, and by the area of the orifice also in feet, and the product is the quantity discharged in cubic feet per second.

Again, if the water flow over the sluice, multiply the square root of the depth in feet by 3·6; and the product multiplied by the length and depth, also in feet, gives the number of cubic feet discharged per second, nearly.

EXAMPLE 1.—Required the number of cubic feet per second that will issue from the orifice of a sluice 5 feet long, 9 inches wide, and 4 feet from the surface of the water.

Here $\sqrt{4} \times 5{\cdot}4 \times 5 \times {\cdot}75 = 2 \times 5{\cdot}4 \times 5 \times {\cdot}75 = 40{\cdot}5$ cubic feet per second. = *Ans.*

* By *head* is understood the distance between the aperture of the sluice and where the water strikes upon the wheel.

EXAMPLE 2.—What quantity of water per second will be expended over a wear, dam, or sluice, whose length is 10 feet, and depth 6 inches?

Here $\sqrt{\cdot 5} \times 3{\cdot}6 \times 10 \times \cdot 5 = \cdot 707107 \times 3{\cdot}6 \times 5 = 12{\cdot}7279$ cubic feet per second. = *Ans.*

In estimating the power of water wheels, half the head must be added to the whole fall, because 1 foot of fall is equal to 2 feet of head; call this the effective perpendicular descent; multiply the weight of the water per second by the effective perpendicular descent and by 60; divide the product by 33000, and the quotient is the effect expressed in horses' power.

EXAMPLE 1.—Given 16 cubic feet of water per second, to be applied to an *undershot* wheel, the head being 12 feet (and the fall = 0); required the power produced.

Here $12 \div 2 = 6$ and $\frac{6 \times 16 \times 62{\cdot}5 \times 60}{33000} =$ 10·9 horses' power, nearly.

EXAMPLE 2.—Given 16 cubic feet of water per second, to be applied to a high breast or an overshot wheel, with 2 feet head and 10 feet fall; required the power.

Here $2 \div 2 = 1$ and $\frac{(1 + 10) \times 16 \times 62{\cdot}5 \times 60}{33000}$ = 20 horses' power.

N.B.—Only about two-thirds of the above results can be taken as real communicative power to machinery.

OF THE CIRCLE OF GYRATION IN WATER WHEELS.

The centre or circle of gyration is that point or circle in a revolving body into which, if the whole quantity of matter were collected or placed, the same moving force would generate the same angular velocity,

which renders it of the utmost importance in the erection of water wheels, and the motion ought always to be communicated from that centre when it is possible.

To find the circle of gyration.

RULE.—Add together twice the weight of the shrouding, buckets, &c., $\frac{2}{3}$ of the weight of the arms, and the weight of the water; multiply the sum by the square of the radius; divide the product by twice the sum of the weight of the shrouding, arms, &c., added to the weight of the water, and the square root of the quotient is the radius of the circle of gyration from the centre of suspension, nearly.

EXAMPLE.—Required the distance of the centre of gyration from the centre of suspension in a water wheel 22 feet diameter, shrouding, buckets, &c., = 18 tons, arms = 12 tons, and water = 10 tons.

Here $\surd \{(2 \times 18 + \frac{2}{3} \times 12 + 10) \times 11^2 \div [(18 + 12) \times 2 + 10]\} = \surd\{(36 + 8 + 10) \times 121 \div (30 \times 2 + 10)\} = \surd\{(54 \times 121) \div 70\} = \surd (6534 \div 70) = \surd 93{\cdot}34 = 9{\cdot}7$ feet from the centre of suspension, nearly.

Table of angles for windmill sails.

The radius is supposed to be divided into six equal parts, and $\frac{1}{6}$ from the centre is called 1, the extremity being denoted by 6.

No.	*Angle with the Plane of Motion.*	
1	18°	24°
2	19	21
3	18	18
4	16	14
5	12½	9
6	7	3 *extremity.*

The first column contains the angles according to Smeaton; but experience has taught us that the angles in the second column are preferable.

THE VELOCITY OF THRESHING MACHINES, MILLSTONES, CUTTERS FOR BORING IRON, &c.

The drum or beaters of a threshing machine ought to move with a velocity of about 3000 feet per minute; hence, divide 11460 by the diameter of the drum in inches; or 955 by the diameter of the drum in feet; and the quotient is the number of revolutions required per minute. And

The feeding rollers must make half the revolutions of the drum, when their diameters are about $3\frac{1}{2}$ inches.

If the machine is driven by horses, their velocity ought to be from $2\frac{1}{2}$ to 3 times round a 24 feet ring per minute.

The velocity of millstones ought to be from about 1550 to 1600 feet per minute; hence, divide 500 by the diameter of a millstone, in feet, or 6000 by the diameter in inches, and the quotient is the number of revolutions required per minute.

In boring cast iron, the cutters ought to have a velocity of about 110 inches per minute; hence, divide 35 by the diameter in inches, the quotient is the number of revolutions of the cutter or boring head per minute.

And divide 100 by the diameter in inches, the quotient is the number of revolutions per minute for turning wrought iron in general, which is about 300 feet per minute, and about half that velocity for cast iron.

OF PUMPS AND PUMPING ENGINES.

Pumps are chiefly designated by the names of "lifting" and "force" pumps. Lifting pumps are applied to wells, &c., where the height of the bucket, from the surface of the water, must not exceed 33 feet; this being nearly equal to the pressure of the atmosphere, or the height to which water would be forced up into a vacuum by the pressure of the atmosphere. Force pumps are applicable on all other occasions, as raising water to any required height, supplying boilers against the force of the steam, hydrostatic presses, &c.

The power required to raise water to any height is as the weight and velocity of the water with an addition of about $\frac{1}{5}$ of the whole power for friction; hence the rule,—Multiply the perpendicular height of the water, in feet, by the velocity, also in feet, and by the square of the pump's diameter in inches, and again by 2·046; divide the product by 165000, and the quotient will be the number of horses' power required.

EXAMPLE.—Required the power necessary to overcome the resistance and friction of a column of water 4 inches diameter, 60 feet high, and flowing with a velocity of 130 feet per minute.

Here $\frac{60 \times 130 \times 4^2 \times 2{\cdot}046}{165000} = \frac{6 \times 13 \times 16 \times 31}{25000}$

$= \frac{6 \times 13 \times 16 \times 124}{100000} = \frac{154752}{100000} = 1{\cdot}55$ horses' power, nearly.

NOTE.—Hot liquor pumps, or pumps to be employed in raising any fluid where steam is generated, require to be placed in the fluid, or as low as the bottom of it, on account of the steam filling the pipes, and acting as a counterpoise to the atmosphere; and the diameter of the pipes to and from a pump ought not to be less than $\frac{3}{4}$ of the pump's diameter.

The diameter of a pump and velocity of the water given, to find the quantity discharged in gallons, or cubic feet, in any given time.

RULE.—Multiply the velocity of the water, in feet per minute, by the number of minutes in the given time, by the square of the pump's diameter in inches, and by ·034 for imperial gallons; or, ·0005456 for cubic feet, and the product will be the number of gallons or cubic feet discharged in the given time, nearly.

EXAMPLE.—What is the number of imperial gallons of water discharged per hour by a pump 4 inches diameter, the water flowing at the rate of 130 feet per minute?

Here $130 \times 60 \times 4^2 \times \cdot034 = 13 \times 6 \times 16 \times 3\cdot4 = 4243\cdot2$ gallons. = *Ans.*

The length of stroke and number of strokes given, to find the diameter of a pump, and number of horses' power that will discharge a given quantity of water in a given time.

RULE 1.—Multiply the number of imperial gallons required in the given time by 353, or the number of cubic feet by 2201, and divide the result by the product of the velocity of the water in inches, and the number of minutes in the given time, the square root of the quotient will be the pump's diameter in inches.

2.—Multiply the number of gallons in the given time by 60, or the number of cubic feet by 375, and by the perpendicular height of the water in feet, divide the result by the product of 165000 and the number of minutes in the given time, then will the quotient be the number of horses' power required.

EXAMPLE.—Required the diameter of a pump, and number of horses' power, capable of filling a cistern 20

feet long, 12 feet wide, and $6\frac{1}{2}$ feet deep, in 45 minutes, whose perpendicular height is 53 feet; the pump to have an effective stroke of 26 inches, and make 30 strokes per minute.

Here $20 \times 12 \times 6{\cdot}5 = 1560$ cubic feet; and $26 \times 30 = 780$, the velocity in inches per minute.

Then, $\sqrt{\frac{1560 \times 2201}{780 \times 45}} = \sqrt{\frac{2 \times 2201}{45}} = \sqrt{\frac{4402}{45}} = \sqrt{\frac{880{\cdot}4}{9}} = \frac{\sqrt{880{\cdot}4}}{3} = \frac{29{\cdot}67}{3} = 9{\cdot}89$ inches diameter of pump. = 1*st Ans.*

Also, $\frac{1560 \times 375 \times 53}{165000 \times 45} = \frac{13 \times 53}{165} = \frac{689}{165} = 4{\cdot}18$ horses' power. = 2*nd Ans.*

To find the time a cistern will take in filling, when a known quantity of water is going in, and a known portion of that water is going out, in a given time.

Rule.—Divide the content of the cistern, in gallons, by the difference of the quantity going in, and the quantity going out, and the quotient is the time in hours and parts that the cistern will take in filling.

Example.—If 30 gallons per hour run in and $22\frac{1}{2}$ gallons per hour run out of a cistern capable of containing 200 gallons, in what time will the cistern be filled?

Here $\frac{200}{30 - 22{\cdot}5} = \frac{200}{7{\cdot}5} = \frac{800}{30} = 26{\cdot}666$, number of hours = 26 hours and 40 minutes. = *Ans.*

To find the time a vessel will take in emptying itself of water.

Mr. Banks ascertained, from very accurate experiments, that a vessel, 3·166 feet long and 2·705 inches diameter, would empty itself in 3 minutes and 16 seconds, through an orifice in the bottom, whose area is ·0141 inches; and another 6·458 feet long, the diameter and orifice as before, would do the same in 4 minutes and 40 seconds; hence, from these experiments a rule is obtained, namely,

Multiply the square root of the depth in feet by the area of the falling surface in inches, divide the product by the area of the orifice, multiplied by 3·7, and the quotient is the time required in seconds, nearly.

EXAMPLE.—How long will it require to empty a vessel of water, 9 feet high, and 20 inches diameter, through a hole $\frac{3}{4}$ inch in diameter?

Here $\sqrt{9} = 3$, the square root of the depth,

And $20^2 \times ·7854 = 400 \times ·7854$ square inches, area of the falling surface,

And $·75^2 \times ·7854 = ·5625 \times ·7854$ square inches, area of the orifice;

Then, $\frac{400 \times ·7854 \times 3}{·5625 \times ·7854 \times 3·7} = \frac{400 \times 3}{·5625 \times 3·7} =$

$\frac{16 \times 400 \times 3}{9 \times 3·7} = \frac{6400}{11·1} = 576·6$ seconds; or,

9 minutes and 37 seconds, *very nearly.* = *Ans.*

On the pressure of fluids.

The side of any vessel containing a fluid sustains a pressure equal to the area of the side, multiplied by half the depth; thus,

Suppose each side of a vessel to be 12 feet long and 5 feet deep, when filled with water, what pressure is upon each side?

12 × 5 = 60 feet, the area of the side,
2·5 feet = half the depth, and
62·5 *lbs.* = the weight of a cubic foot of water.

Then, 60 × 2·5 × 62·5 = 9375 *lbs.* = *Ans.*

To find the number of imperial gallons contained in a yard of circular pipe, of any given diameter.

Rule.—Multiply the square of the diameter of the circular pipe in inches by ·102, the product will be the content of the pipe in imperial gallons nearly.

Example 1.—Required the number of imperial gallons contained in each yard of a $6\frac{1}{4}$ inch circular pipe.

Here $6{\cdot}25^2 \times {\cdot}102 = 39{\cdot}0625 \times {\cdot}102 = 3{\cdot}984375$ imperial gallons. = *Ans.*

Example 2.—Required the content of a yard of 4 inch circular pipe in imperial gallons.

Here $4^2 \times {\cdot}102 = 16 \times {\cdot}102 = 1{\cdot}632$ imperial gallons. = *Ans.*

To find the weight that a given power can raise by one of Bramah's pumps, or hydrostatic presses.

Rule.—Multiply the square of the diameter of the ram in inches by the power applied in *lbs.*, and by the effective leverage of the pump handle; divide the product by the square of the pump's diameter, also in inches, and the quotient is the weight that the power is equal to.

Example.—What weight will a power of 50 *lbs.* raise by means of an hydrostatic press, whose ram is

7 inches diameter, pump $\frac{7}{8}$, and the effective leverage of the pump handle being as 6 to 1?

Here $\frac{7^2 \times 50 \times 6}{\cdot 875^2} = \frac{7^2 \times 8^2 \times 50 \times 6}{7^2} = 64 \times 300 = 19200$ *lbs.*, or 8 *tons* 11 *cwt.* = *Ans.*

In the following rules for pumping engines the boiler is supposed to be loaded with about $2\frac{1}{2}$ *lbs.* per square inch, and the barometer attached to the condenser indicating 26 inches on an average, or 13 *lbs.*, making altogether $15\frac{1}{2}$ *lbs.*, from which deducting $\frac{1}{3}$ for friction, leaves a pressure of 10 *lbs.* nearly upon each square inch of the piston.

To find the diameter of a cylinder to work a pump of a given diameter for a given depth.

RULE.—Multiply the pump's diameter in inches by the square root of $\frac{1}{3}$ of the depth of the pit in fathoms, and the product will be the cylinder's diameter in inches.

EXAMPLE.—Required the diameter of a cylinder to work a pump 12 inches diameter for a depth of 27 fathoms.

Here $12 \times \sqrt{\frac{27}{3}} = 12 \times \sqrt{9} = 12 \times 3 = 36$ inches diameter. = *Ans.*

To find the diameter of a pump that a cylinder of a given diameter can work at a given depth.

RULE.—Multiply the cylinder's diameter in inches by the square root of 3 times the depth of the pit in fathoms, and divide the product by the depth of the pit in fathoms, the quotient will be the pump's diameter in inches.

EXAMPLE.—What diameter of a pump will a 36 inch cylinder be capable of working 27 fathoms deep?

Here $\frac{36 \times \sqrt{(3 \times 27)}}{27} = \frac{36 \times \sqrt{81}}{27} = \frac{4 \times 9}{3} =$

$4 \times 3 = 12$ inches diameter. = *Ans.*

To find the depth from which a pump of a given diameter will work by means of a cylinder of a given diameter.

RULE.—Divide three times the square of the cylinder's diameter in inches by the square of the pump's diameter also in inches, and the quotient will be the depth of the pit in fathoms.

EXAMPLE.—Required the depth that a cylinder of 36 inches diameter will work a pump of 12 inches diameter.

Here $\frac{36^2 \times 3}{12^2} = 3^2 \times 3 = 27$ fathoms. = *Ans.*

APPROXIMATE RULES FOR CALCULATING LIQUIDS.

To find the number of imperial gallons contained in any square or rectangular cistern.

RULE.—Multiply the content of the cistern in cubic feet by 6·232, or the content in cubic inches by ·003607, and the product is the number of gallons nearly.

EXAMPLE.—A cistern is 8 feet long, $4\frac{1}{2}$ feet wide, and 3 feet deep, required its contents in imperial gallons.

Here $8 \times 4{\cdot}5 \times 3 = 108$ cubic feet,
And $108 \times 6{\cdot}232 = 673{\cdot}056$ gallons. = *Ans.*

Or, 8 feet = 96 inches; $4\frac{1}{2}$ feet = 54 inches; and 3 feet = 36 inches;
Then, $96 \times 54 \times 36 = 186624$ cubic inches,
And $186624 \times {\cdot}003607 = 673{\cdot}153$ gallons. = *Ans. as before, nearly.*

Any two dimensions of a square or rectangular cistern being given, to find the third, that shall contain any number of imperial gallons required.

RULE.—Multiply the number of gallons that the cistern is required to contain by ·16046 for feet, or by 277·274 for inches, according as the dimensions are given in feet or inches, divide this product by the products of the two given dimensions, and the quotient will be the third dimension of the cistern nearly.

EXAMPLE.—Required the depth of a cistern to contain 800 imperial gallons, the length being $6\frac{1}{2}$ feet, and width $4\frac{3}{4}$ feet.

Here $\frac{800 \times {\cdot}16046}{6\frac{1}{2} \times 4\frac{3}{4}} = \frac{8 \times 128{\cdot}368}{13 \times 19} = \frac{1026{\cdot}944}{247} =$ 4·16 feet deep. = *Ans.*

To find the content of a cylinder in imperial gallons.

RULE.—Multiply the square of the diameter in feet by the length of the cylinder, also in feet, and by 4·895;

Or, multiply the square of the diameter in inches by the length in feet, and by ·034;

Or, multiply the square of the diameter in inches by the length, also in inches, and by ·00283′, and the product will be the content in gallons, nearly.

EXAMPLE.—How many imperial gallons are contained in a circular well $22\frac{1}{2}$ feet deep, and $3\frac{1}{2}$ feet diameter?

Here $3{\cdot}5^2 \times 22{\cdot}5 \times 4{\cdot}895 = 1349$ gallons. = *Ans.*

Or, $3\frac{1}{2}$ feet = 42 inches,

And $42^2 \times 22{\cdot}5 \times {\cdot}034 = 1349$ gallons. = *Ans. as before.*

Also, $22\frac{1}{2}$ feet = 270 inches,

And $42^2 \times 270 \times {\cdot}00283' = 1349$ gallons. = *Ans. as before.*

The length of a cylinder given, to find the diameter, or the diameter given, to find the length that shall contain any number of imperial gallons required.

RULE.—Multiply the number of gallons that the cylinder is required to contain by ·2043, divide the product by the length in feet, and the square root of the quotient is the diameter in feet, and parts of a foot;

Or, multiply the number of gallons by ·2043, and divide the product by the square of the diameter in feet, and the quotient is the length in feet and parts of a foot;—and

If the dimensions are in inches in place of feet, use 353 in place of ·2043.

EXAMPLE.—What must be the diameter of a cylinder to contain 5 imperial gallons, when the length is 20 inches?

Here $\sqrt{\left(\frac{353 \times 5}{20}\right)} = \sqrt{\frac{353}{4}} = \frac{1}{2} \times \sqrt{353} =$

$\frac{18{\cdot}8}{2} = 9{\cdot}4$ inches diameter. = *Ans.*

The cube of the diameter of a sphere in feet, multiplied by 3·263 = imperial gallons;

Or, the cube of the diameter of a sphere in inches, multiplied by ·001888 = imperial gallons.

Note.—The weight of a cubic foot of water = 62·5 *lbs.* avoirdupois.

Weight of a cubic inch = ·03617 *lbs.* avoirdupois.

Weight of a column of water 12 inches high and 1 inch square = ·434 *lbs.* avoirdupois.

Weight of a cylindrical foot of water = 49·1 *lbs.* avoirdupois.

Weight of a cylindrical inch = ·02842 *lbs.* avoirdupois.

Weight of a cylindrical column of water 12 inches high and 1 inch diameter = ·341 *lbs.* avoirdupois.

Take, for example, a cylindrical column of water 11 inches diameter and 15 feet high, required its weight.

Here $11^2 \times 15 \times {\cdot}341 = 618{\cdot}915$ *lbs.* avoirdupois.

11·2 imperial gallons of water = 1 *cwt.*
224 imperial gallons of water = 1 *ton.*
1·8 cubic feet of water ..... = 1 *cwt.*
35·84 ditto ..... = 1 *ton.*
1 ditto ..... = 6·238 *imperial gallons.*
1 cylindrical foot of ditto .... = 4·895 *imperial gallons.*

OF STEAM AND THE STEAM ENGINE.

Steam is the visible moist vapour which arises from all bodies that contain juices easily expelled from them by heats not sufficient for their combustion.

But steam, as applicable at present to the steam engine, is highly rarified water, the particles of which are expanded by the absorption of caloric, or the matter of heat.

Water rises in vapour at all temperatures, but is confined to the surface of the fluid acted upon until it has attained 212° Fahrenheit, called the boiling point; at that heat steam ascends through it, preventing its elevation to a higher temperature by carrying the heat off in a latent form.

The latent heat of steam at the common pressure of the atmosphere, according to very accurate experiments, is found to be 1000°; and we know that the sensible, or thermometric heat = 212°. Now 212° − 32° = 180° and 1000° + 180° = 1180°; therefore, steam at 212° is highly rarified water, containing 1180° of heat; hence, to find the latent heat of steam at any other temperature, subtract the sensible heat from 1180°, and the difference + 32° = the latent heat.

EXAMPLE.—Required the latent heat of steam whose sensible heat is 224°.

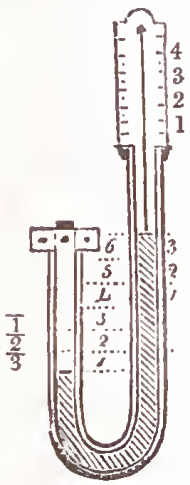
Here 1180° − 224° = 956°,

And 956° + 32° = 988° latent heat. = *Ans.*

One cubic inch of water produces about 1700 cubic inches of steam at 212°, or the common pressure of the atmosphere; but the boiling point varies considerably, according to the pressure on the surface of the fluid, and, of course, materially affects the density of the vapour produced; thus, in a vacuum, water boils at about 90°; under common pressure, at 212°; and when pressed with a column of mercury 5 inches in height, will not boil

until heated to 217°; each inch of mercury producing by its pressure a rise of about 1° in the thermometer.

The pressure or force of steam in the boiler (less than the weight upon the safety valve) is generally indicated by a column of mercury in a bent iron tube, which causes the range of the float to be only half the range of the mercury, 2 inches of mercury being nearly equal to 1 *lb.* pressure of steam in the boiler, thus:—

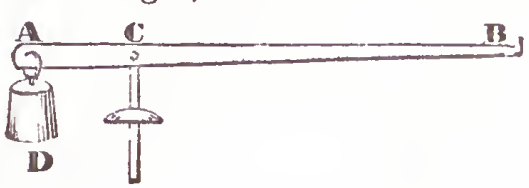


Each inch of the float indicates a pressure of 1 *lb. nearly.*

—Level of the mercury when there is no pressure of steam.

To calculate the effect of a lever and weight upon the safety valve of a steam boiler, &c.

The lever, in all cases, is supposed to be made, finished, and balanced, by a known weight or weights, on the short end, making that point where it rests, or is attached to the valve, the centre of motion; then that weight, added to the weight of the lever, is the effective weight upon the valve, independent of any other additional weight, thus:—



Then there are three different ways that it may be required to calculate the lever.

1.—*When a certain pressure may be required upon the valve, the distance of the weight upon the lever, and distance of the valve from the centre of motion given, to find what weight will be required upon the lever at that distance.*

RULE.—From the required pressure on the valve in *lbs.* subtract the weight of the valve, plus the effective weight of the lever, multiply the remainder by the distance between the fulcrum and the valve, divide the product by the distance between the fulcrum and the weight, and the quotient is the weight in *lbs.* required to be placed upon the lever at that distance.

2.—*When a certain pressure upon the valve is required, the weight upon the lever and distance of valve from the centre of motion given, to find where that weight must be placed.*

RULE.—From the required weight upon the valve in *lbs.* subtract the weight of the valve, plus the effective weight of the lever, multiply the remainder by the distance between the fulcrum and the valve, divide the product by the weight in *lbs.* upon the lever, and the quotient is the distance in inches from the fulcrum that the weight must be placed.

3.—*When the distance of weight, distance of valve from the centre of motion, and weight upon the lever are given, to find what pressure is upon that valve.*

RULE.—Multiply the weight in *lbs.* upon the lever by the distance in inches to the fulcrum, divide the product by the distance between the fulcrum and the valve, and the quotient, plus the weight of the valve and effective weight of the lever, equals the weight upon the valve in *lbs.*

EXAMPLE 1.—Suppose the lever A B (as above) to be 24 inches in length, and the valve C placed 5 inches

from the centre of motion A, what weight must be placed upon the lever 20 inches from A, to equal 80 *lbs.* on the valve C, the weight of the lever being 2 *lbs.*, the weight D, which balances the lever, $4\frac{1}{2}$ *lbs.*, and the weight of the valve 3 *lbs.?*

Here 2·0 *lbs.* weight of the lever.
4·5 *lbs.* to balance ditto.
3·0 *lbs.* weight of the valve.

Sum = 9·5 *lbs.* then $\frac{(80 - 9{\cdot}5) \times 5}{20} = \frac{70{\cdot}5 \times 5}{20} = \frac{70{\cdot}5}{4} = 17{\cdot}625$ *lbs.* = *Ans.*

Example 2.—Suppose, as in the last example, the weight upon the lever equal 17·625 *lbs.*, it is required at what distance from A the weight must be placed to equal 80 *lbs.* at C.

Here $\frac{(80 - 9{\cdot}5) \times 5}{17{\cdot}625} = \frac{70{\cdot}5 \times 5}{17{\cdot}625} = \frac{70{\cdot}5 \times 20}{70{\cdot}5} =$ 20 inches. = *Ans.*

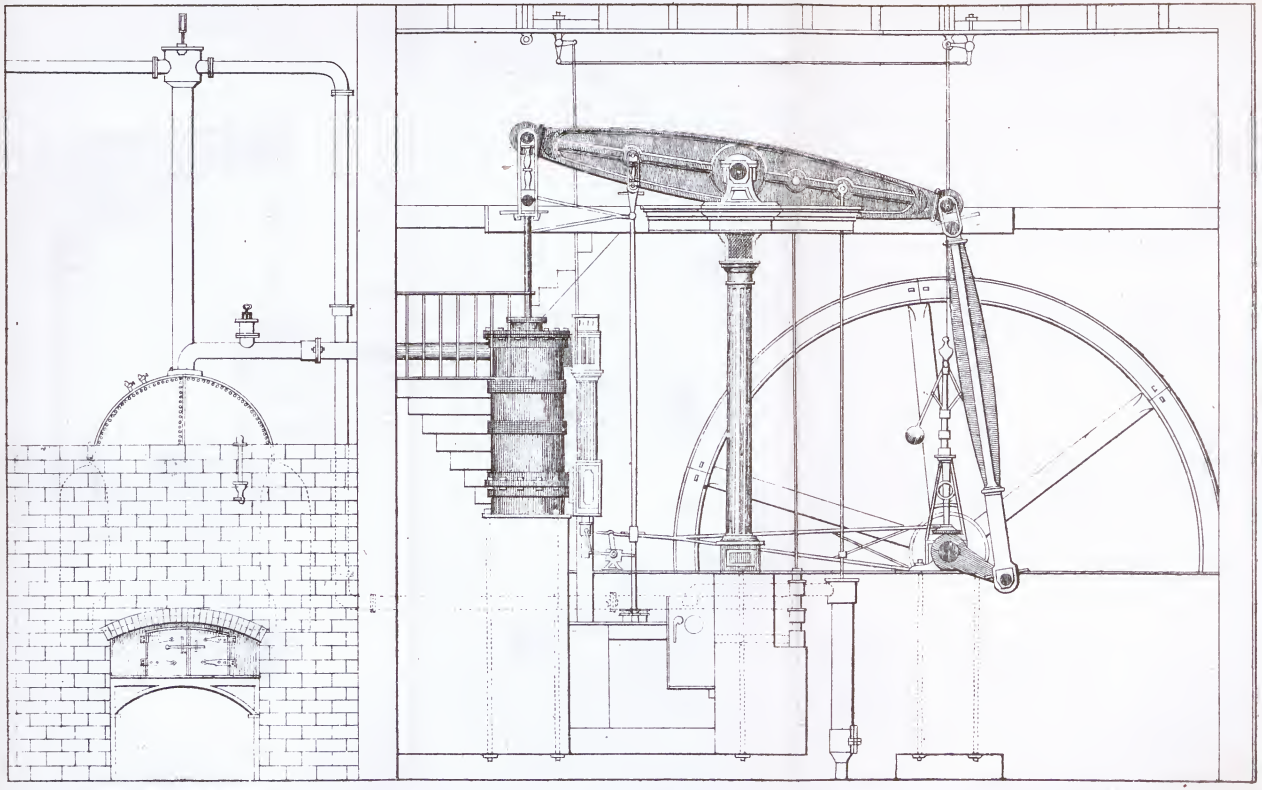
Example 3.—Suppose, as before, that a weight of 17·625 *lbs.* is placed upon the lever 20 inches from A, required the pressure at C, the distance from the centre of motion being 5 inches, and the effective weight of the lever at that point equal $6\frac{1}{2}$ *lbs.*, also the weight of the valve 3 *lbs.*

Here $\frac{17{\cdot}625 \times 20}{5} = 17{\cdot}625 \times 4 = 70{\cdot}5$ *lbs.* to which
6·5 *lbs.*
3·0 *lbs.* } add

Sum = 80 *lbs.* = *Ans.*

To find the proper diameter for a safety valve.

Rule.—Multiply the bottom surface of the boiler, or surface immediately exposed to the action of the fire, in feet, by the multiplier opposite to the pressure in *lbs.* on each square inch of the safety valve, and the square root of the product is the valve's diameter in inches at



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LITHOGRAPHED BY R.H. FRASER, LIVERPOOL

A CONDENSING ENGINE ON THE MOST IMPROVED PRINCIPLE.

the narrowest part. If the boiler is to have two safety valves, then the square root of half the product equals the diameter of each.

Pressure in *lbs.* per square inch.	Multipliers.	Pressure in *lbs.* per square inch.	Multipliers.
3	·356	15	·315
4	·353	20	·305
5	·348	25	·293
6	·344	30	·289
7	·339	35	·282
8	·336	40	·275
10	·329	45	·270
12	·321	50	·264

Table of the elastic force of steam on a square inch.

Steam with a pressure of	*lbs.* on a square inch, equal	*lbs.* on a circular inch; and to maintain that pressure requires to be kept at a uniform temperature of	° F	and will support a column of mercury	inches in height.
2½	1·963		220		5·15
3	2·356		222		6·18
3½	2·749		223½		7·21
4	3·142		225½		8·24
4½	3·534		227		9·27
5	3·927		228½		10·3
5½	4·320		230		11·3
6	4·712		231½		12·3
6½	5·105		233		13·4
7	5·498		234		14·4
7½	5·888		235		15·4
8	6·283		236		16·5
8½	6·676		237½		17·5
9	7 068		239		18·5
9½	7·461		240		19·6
10	7·854		241		20·6
10½	8·247		242		21·6
11	8·639		243		22·6
11½	9·032		244		23·7
12	9·424		245½		24·7
15	11·78		252		30·9
20	15·71		261		41·2
25	19·63		269		51·5
30	23·56		276		61·8
35	27·49		283		72·1
40	31·42		289		82·4
45	35·34		294½		92·7
50	39·27		300		103

Multiply the degrees of heat in either this or the following table by ·06, and the product will be the superficial feet of flue plate exposed to the action of the fire for each horse power.

And multiply the degrees of heat by ·41, and the product will be the areal inches of furnace bar for each horse power.

Table of the elastic force of steam on a circular inch.

Steam with a pressure of	*lbs.* on a circular inch, equal	*lbs.* on a square inch; and to maintain that pressure requires to be kept at a uniform temperature of	° F	and will support a column of mercury	inches in height.
2½	3·183		222½		6·56
3	3·820		224½		7 87
3½	4·456		226½		9·18
4	5·093		228½		10·5
4½	5·729		230½		11·8
5	6·366		232		13·1
5½	7·002		234		14·4
6	7·639		235½		15·7
6½	8·276		236½		17·0
7	8·912		238½		18·3
7½	9·549		239½		19·7
8	10·19		241		21·0
8½	10·82		242½		22·3
9	11·46		244		23·6
9½	12·09		245½		24·9
10	12·73		247		26·2
10½	13·36		248½		27·5
11	14·00		250		28·9
11½	14·64		251		30·1
12	15·28		252½		31·5
15	19·10		259		39·3
20	25·46		270		52·5
25	31·83		278½		65·6
30	38·20		287		78·7
35	44·56		294		91·8
40	50·93		300½		105
45	57·29		305		118
50	63·66		309		131

Proportions of fuel.

The proportion that various substances bear to each other in producing heats sufficient to raise equal quan-

tities of water to equal temperatures is nearly as follows:

Coke.....	0·375	Culm or Slack..	1·875
Coal	1·000	Wood	2·875

Hence, multiply the degrees of heat in either of the preceding tables by the following numbers opposite the material by which the steam is to be produced, and the product will be the weight in *lbs.* avoirdupois that is required on an average per hour for each horse power:

Coke	·024	Slack	·118
Coal	·063	Wood	·180

To find the height of a column of water to supply a steam boiler against any pressure of steam required.

RULE.—Multiply the pressure in pounds (upon a square inch of the boiler) by 2·5, and the product will be the height in feet above the surface of water in the boiler.

EXAMPLE.—Required the length of feed pipe capable of supplying a boiler with water when the pressure of steam is 4 pounds per square inch.

Here $2{\cdot}5 \times 4 = 10$ *feet* above the surface of the water in the boiler. = *Ans.*

STEAM ENGINE is the name of a machine which derives its moving powers from the elasticity and condensibility of steam.

Steam, to produce a maximum of useful effect as a moving power, requires to be reduced to a certain determined velocity, and although this maximum velocity has been exhibited to the public by various eminent writers upon the steam engine, still discrepancies exist amongst practical engineers; and no universally acknowledged rules have as yet been established: however, the following tables may be relied upon as exhibiting the results deduced from the most celebrated

rules, and tested by many engines doing the greatest amount of duty, as proved by accurate trials with indicators of the most recent and approved construction.

Length of Stroke in *ft.* and *in.*	Number per Minute.	Velocity in Feet per Minute.	Length of Stroke in *ft.* and *in.*	Number per Minute.	Velocity in Feet per Minute.
2 0	43	172	4 6	24¼	218¼
2 6	38	190	5 0	22	220
3 0	34	204	6 0	19	228
3 6	30	210	7 0	17½	245
4 0	27	216	8 0	16	256

N.B.—These are to be considered as the velocities of land engines, or engines whose connecting rods are not less than three times the length of stroke; but marine engines, being generally confined to connecting rods of not more than 2 or 2½ times the length of stroke, have their maximum velocities considerably reduced. Hence, the subjoined table will be found pretty correct when the periphery of the wheels moves with a velocity of about 1300 feet per minute, and the floats or paddle boards calculated by the following rules, which I have found, in practice, to produce the greatest satisfaction; namely, economizing of fuel, a steady supply of steam, without waste, and the vessel propelled quicker than when the surface of the floats was less, and moving at a greater velocity.

Table of velocities for marine engines.

Length of Stroke in *ft.* and *in.*	Number per Minute.	Velocity in Feet per Minute.	Length of Stroke in *ft.* and *in.*	Number per Minute.	Velocity in Feet per Minute.
2 0	42	168	4 0	24	192
2 3	39½	177¾	4 6	21½	193½
2 6	36	180	5 0	20	200
2 9	33	181½	5 6	19	209
3 0	31	186	6 0	18	216
3 6	27	189	7 0	15¾	220½

To find the surface of the floats or paddle boards.

RULE 1.—Multiply the number of horses' power that the engine is equal to by $3\frac{3}{4}$, divide the product by the diameter of the wheel in feet, and the quotient is the area of each float, or paddle board.

RULE 2.—Multiply the number of horses' power by $2\frac{1}{4\,0}$, divide this product by the diameter, and the quotient is the length in feet.

RULE 3.—The breadth is 1 foot 10 inches.

EXAMPLE.—Required the area, length, and breadth of each paddle board, for a steam vessel with two engines of 80-horse power each, and wheels of 20 feet diameter.

Here $\frac{80 \times 3\frac{3}{4}}{20} = 3\frac{3}{4} \times 4 = 15$ feet area. = 1*st Ans.*

Then $\frac{80 \times 2\frac{1}{4\,0}}{20} = 4 \times 2\frac{1}{4\,0} = 8\frac{1}{1\,0}$ = length of each board. = 2*nd Ans.*

And 1 foot 10 inches the breadth. = 3*rd Ans.*

And when there is only one engine in the vessel, take $\frac{2}{3}$ of the area, and length found as above.

Each wheel, from 12 to 14 feet diameter, ought to have 12 floats; from 14 to 16 feet diameter, 14 floats; from 16 to 18 feet diameter, 16 floats; and from 18 to 22 feet diameter, 18 floats, &c. (which is nearly 1 float to each foot of the diameter.)

Principles upon which the rule is founded for calculating the power of a steam engine.

Hitherto it has been customary, in estimating the power of condensing engines, to reckon the force of

the steam at a constant quantity, namely, $2\frac{1}{2}$ *lbs.* per circular inch, totally disregarding any extra pressure in the boiler, or increased weight upon the safety valve.

Hence, in order to form a rule whereby to approximate more nearly to the real effective power of the engine, it was necessary first to ascertain the effective force of the steam,—And,

To determine this, I recently made a series of experiments upon engines without any extra lap upon the valves, whereby to work expansively, when I found that, on account of the nature of the valve's motion, only about three-fourths of the stroke was performed by steam at, or near, the density of the steam in the boiler, the stroke, of course, being terminated expansively; hence, the whole effective force of the steam thus applied can only be taken at about four-fifths of its original pressure.

The benefit arising from the condenser is on an average equal to 26 inches of mercury, or about 13 *lbs.* per square inch; consequently, 13 plus four-fifths of the pressure on each square inch of the safety valve, equals the whole effective force on each square inch of the piston's area.

Then about $8\frac{1}{4}$ *lbs.* are expended in overcoming the resistance and friction of a condensing engine, and may be thus estimated: 13 minus $8\frac{1}{4}$ equals $4\frac{3}{4}$, and $4\frac{3}{4}$ plus $\frac{4}{5}$ths of the weight upon each square inch of the safety valve equals the whole amount of useful effect in giving motion to machinery.

The process of calculation may be simplified thus: $4\frac{3}{4}$ *lbs.* per square inch $= 3{\cdot}73$ *lbs.* per circular inch, by which means the circle only requires to be squared, and the labour of multiplying by ·7854 is dispensed with.

GENERAL RULES.

1.—Multiply the square of the cylinder's diameter in inches by 3·73 plus $\frac{4}{5}$ths the pressure on each circular

inch of the safety valve, and by the velocity of the piston in feet per minute; divide the product by 33000, and the quotient is the effect of the engine expressed in horses' power.

EXAMPLE.—Suppose a cylinder $24\frac{1}{2}$ inches diameter, stroke 4 feet, or 200 feet velocity per minute, and the weight upon the safety valve 3·5 *lbs.* per circular inch, required the effective power.

Here $\frac{4}{5}ths$ of 3·5 = 2·8, and 3·73 + 2·8 = 6·53 *lbs.* effective force.

Then, $\frac{24{\cdot}5^2 \times 6{\cdot}53 \times 200}{33000} = \frac{49^2 \times 6{\cdot}53 \times 2}{2^2 \times 330} = \frac{2401 \times 6{\cdot}53}{660} = \frac{2401 \times {\cdot}653}{66} = \frac{1568}{66} = 24$ horses' power. = *Ans.*

2.—Multiply 33000 by the number of horses' power required, and divide the product by the velocity of the piston in feet per minute, multiplied by 3·73 plus $\frac{4}{5}ths$ the pressure on each circular inch of the safety valve, and the square root of the quotient is the cylinder's diameter in inches.

EXAMPLE.—Required the diameter of a cylinder for an engine of 30 horses' power, with a 6-feet stroke, or 228 feet per minute, and steam at $2\frac{1}{2}$ *lbs.* per circular inch.

Here $\frac{4}{5}ths$ of 2·5 = 2; and 3·73 + 2 = 5·73 *lbs.* effective force.

Hence $\sqrt{\frac{33000 \times 30}{228 \times 5{\cdot}73}} = \sqrt{\frac{990000}{228 \times 5{\cdot}73}} = \sqrt{\frac{247500}{57 \times 5{\cdot}73}} = \sqrt{\frac{247500}{326{\cdot}61}} = \sqrt{758} = 27{\cdot}53$ inches diameter. = *Ans.*

NOTE.—To obtain four-fifths of the pressure of steam, multiply the original pressure by 4 and divide by 5, the quotient is the pressure required.

Or, subtract from the original pressure its fifth part.

The above are to be taken as general practical rules for engines not working expansively further than what is compulsory from the nature of the slide valve; but where engines are worked more expansively, and greater accuracy required, recourse must be had to the following rules for obtaining the uniform force of the steam.

RULE 1.—Divide the length of the stroke in inches by the distance (also in inches) that the piston moves before the steam is shut off, and divide the pressure on the boiler in *lbs.* by *the quotient:*—

2.—Add 1 to the hyperbolic logarithm of the first quotient, which is the number of times to which the steam is expanded, and multiply the sum by the second quotient, which is the number of *lbs.* to which the steam is expanded, and the product is the uniform force of the steam acting throughout the whole stroke.

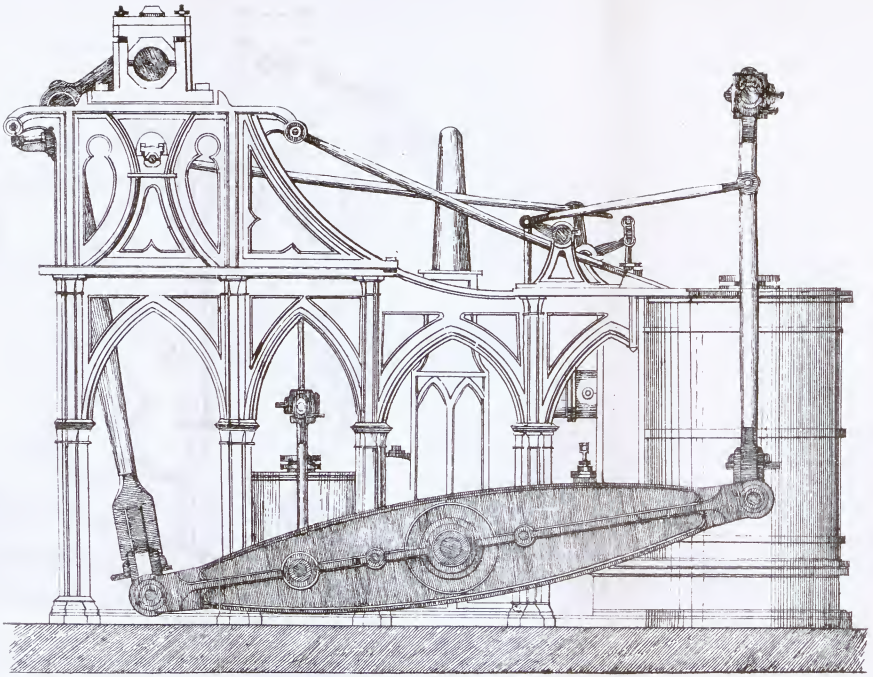
EXAMPLE.—Let the steam in the boiler of an engine equal 45 *lbs.* per inch, the length of stroke 4 feet, and the steam to be shut off after the piston has moved 16 inches; required an equivalent force of steam in the cylinder.

Here 4 feet = 48 inches, and $48 \div 16 = 3$, the first quotient.

Then, $45 \div 3 = 15$ *lbs.*, the second quotient.

And $1 + \text{hyp. log. } 3 = 1 + 1{\cdot}0986123 = 2{\cdot}0986123$.

Hence $2{\cdot}0986123 \times 15$ *lbs.* $= 31{\cdot}4791845$ *lbs.* uniform force of the steam. = *Ans.*



PUBLISHED BY SIMPKIN, MARSHALL & CO LONDON.

LITHOGRAPHED BY P. H. FRASER, LIVERPOOL.

AN 80 HORSE MARINE STEAM ENGINE made by GEO. FORRESTER & Co OF L'POOL.

HYPERBOLIC LOGARITHMS.

No.	Logarithms.	No.	Logarithms.	No.	Logarithms.	No.	Logarithms.
$1\frac{1}{4}$	·2231436	$3\frac{1}{4}$	1·1786550	$5\frac{1}{4}$	1·6582281	$7\frac{1}{4}$	1·9810015
$1\frac{1}{2}$	·4054651	$3\frac{1}{2}$	1·2527630	$5\frac{1}{2}$	1·7047481	$7\frac{1}{2}$	2·0149030
$1\frac{3}{4}$	·5596158	$3\frac{3}{4}$	1·3217558	$5\frac{3}{4}$	1·7491999	$7\frac{3}{4}$	2·0476928
2	·6931472	4	1·3862944	6	1·7917595	8	2·0794415
$2\frac{1}{4}$	·8109302	$4\frac{1}{4}$	1·4469190	$6\frac{1}{4}$	1·8325815	$8\frac{1}{2}$	2·1400662
$2\frac{1}{2}$	·9162907	$4\frac{1}{2}$	1·5040774	$6\frac{1}{2}$	1·8718022	9	2·1972246
$2\frac{3}{4}$	1·0116009	$4\frac{3}{4}$	1·5581446	$6\frac{3}{4}$	1·9095425	$9\frac{1}{2}$	2·2512918
3	1·0986123	5	1·6094379	7	1·9459101	10	2·3025851

THE STEAM WAY.

Multiply the square of the cylinder's diameter by ·08, and divide the product by 3, the quotient will be the area of port or steam way.

EXAMPLE.—What area of port or steam way is necessary for a cylinder 36 inches diameter?

Here $\frac{36^2 \times \cdot 08}{3} = 36 \times 12 \times \cdot 08 = 432 \times \cdot 08 =$ 34·6 inches area of steam way. = *Ans.*

OF THE SLIDE VALVE.

When the valve is at the middle of its stroke, the faces ought to cover the apertures on the exhausting side about $\frac{1}{10}$ of an inch; the cover on the steam side being for the purpose of cutting off the steam at any part of the stroke, is, therefore, at the entire discretionary judgment of the engineer. However, we find from practice, that high-pressure engines with short strokes, as locomotives, &c., require no more than will cover the apertures properly; whereas condensing engines, with steam of $2\frac{1}{2}$ to 3 *lbs.* per square inch, will work well with $\frac{5}{8}$ of an inch cover on the steam side; and marine engines give great satisfaction with $1\frac{3}{8}$ inches cover, when the steam is $4\frac{1}{2}$ *lbs.* to 5 *lbs.* per square inch.

Again, the lead of the valve (as it is termed amongst engineers) is a certain distance that the extremity of the eccentric must be in advance of the crank, so that the valve may be open as required when the piston is at the top or bottom of the cylinder,—for this reason, that, at the return of the stroke, the steam in the cylinder may be of, or nearly, an equal density with the steam in the boiler: consequently, the nearer that the length of the aperture is to the area of the cylinder, the less lead is required. Thus,

Suppose a cylinder of 48 inches diameter, with an aperture 16 inches long, $\frac{48^2}{16} = 144$; and another 24 inches diameter, with an aperture 8 inches long, $\frac{24^2}{8} = 72$; then $\frac{144}{72} = 2$. Hence it is evident that although both apertures bear the same ratio to the diameter of the cylinder, and both valves move the same distance, the 48 inch cylinder would be twice the time in filling with steam to that of the 24 inch, for a cylinder twice the diameter is four times the area; but scarcely two engineers agree upon this point. However, the following is an approximate rule to a number of celebrated working engines, namely: multiply the square of the cylinder's diameter in inches by ·002, and divide the product by the length of the aperture, also in inches; the quotient will be the width that the valve must be open when the piston is exactly at the top or bottom of the cylinder.

Example.—Let a cylinder be 30 inches diameter, with an aperture 12 inches long.

Here $\frac{30^2 \times \cdot002}{12} = \frac{900 \times \cdot001}{6} = \frac{\cdot9}{6} = \cdot15$ parts of an inch for the aperture to be open at the return of the stroke. = *Ans.*

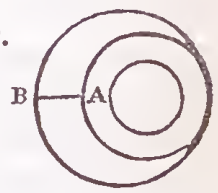
THE ECCENTRIC.

1.—The length of the levers on the weigh or traverse shaft given, to find the required throw of the eccentric.

RULE.—Multiply the distance that the valve is to travel by the length of the lever on the weigh shaft for the eccentric rod; divide the product by the length of the lever for working the valve, and the quotient is the throw of the eccentric.

EXAMPLE.—Let a valve be required to travel 6 inches, the lever on the weigh shaft for working the valve 12 inches in length, and the lever for the eccentric rod 10 inches; required the throw of that eccentric.

Here $\frac{6 \times 10}{12} = 5$ inches throw. = *Ans.*



The throw of the eccentric is the distance between A and B on that eccentric.

2.—The throw of the eccentric and the stroke of the valve, also one of the levers on the weigh shaft given, to find the other.

RULE.—Multiply the throw of the eccentric by the length of the lever to work the valve, and divide by the distance the valve is to travel; the quotient will be the length of the other lever. *Or,*

Multiply the travel of the valve by the length of the lever on the weigh shaft, for the eccentric rod, and divide by the throw of the eccentric; the quotient will be the length of the lever for working the valve.

EXAMPLE.—Suppose a valve be required to travel 6 inches, the throw of the eccentric 5, and the length of the lever on the weigh shaft for working equal 12 inches; required the length of the other.

$$\text{Here } \frac{5 \times 12}{6} = 10 \text{ inches;}$$

$$\textit{Or, } \frac{6 \times 10}{5} = 12 \text{ inches.}$$

THE COLD WATER PUMP.

Taking practice for the data whereby to determine the quantity of water sufficient for condensation in all ordinary cases of the steam engine, I find that, at the common temperature of the atmosphere, four imperial gallons of water to each horse power are quite capable of condensing steam at 220° Fahr. to water at 80°; but if the temperature of the steam be raised, the quantity of water must be augmented, according to the result of the following

RULE.—Multiply the temperature of the steam in the boiler by ·019, and the product will be the quantity required in imperial gallons per minute to each horse power. Hence, to find the diameter of the pump, when the stroke is given, or the stroke of the pump, when the diameter is given,

Multiply the quantity required in gallons for each horse power by the number of horses' power that the engine is equal to, and by 353; divide the product by the intended stroke of the pump in inches multiplied by the number of strokes per minute, and the square root of the quotient is the pump's diameter in inches. And when the pump's diameter is given and the length of the stroke required, divide the product by the number of strokes per minute multiplied by the square of the pump's diameter, and the quotient is the length of the stroke.

EXAMPLE.—Let an engine of 25 horses' power be propelled by steam at 7 *lbs.* per square inch, what must be the pump's diameter when the stroke is 23 inches, and making 22 strokes per minute?

Here 7 *lbs.* per square inch (see Table, *p.* 127) = 234°;
And 234 × ·019 = 4·446 gallons to each horse power.

Then, $\sqrt{\frac{4{\cdot}446 \times 25 \times 353}{23 \times 22}} = \sqrt{\frac{111{\cdot}15 \times 353}{506}}$
$= \sqrt{77{\cdot}54} = 8{\cdot}8$ inches diameter, nearly. = *Ans.*

And when the pump's diameter is given, as above, we have

$\frac{4{\cdot}446 \times 25 \times 353}{77{\cdot}54 \times 22} = 23$ inches, length of stroke.

NOTE.—The diameter of the injection cock ought to be at least equal to $\frac{1}{15}th$ of the cylinder's diameter.

To find the necessary quantity of water for a boiler.

RULE.—Add 15 to the pressure on each square inch of the boiler in *lbs.*, divide the sum by 90, and the quotient is the quantity in imperial gallons per minute for each horse power. Hence, the rule for the cold water pump is also applicable for the hot water pump.

EXAMPLE.—Suppose a 6-horse engine to be propelled by steam at 30 *lbs.* per square inch, stroke of pump 9 inches, and making 45 strokes per minute, required the pump's diameter.

Here $\frac{30 + 15}{90} = \frac{45}{90} = \frac{1}{2}$ a gallon per minute to each horse power.

Then, $\sqrt{\frac{\frac{1}{2} \times 6 \times 353}{45 \times 9}} = \frac{1}{3}\sqrt{\frac{353}{15}} = \frac{1}{3 \times 15}\sqrt{(353 \times 15)} = \frac{\sqrt{5295}}{45} = \frac{72{\cdot}8}{45} = 1{\cdot}6$ inches diameter. = *Ans.*

And when the pump's diameter is given, as above, we have

$\frac{\frac{1}{2} \times 6 \times 353}{45 \times 1{\cdot}6^2} = \frac{353}{15 \times 2{\cdot}56} = \frac{353}{38{\cdot}4} = 9$ inches length of stroke.

THE AIR PUMP.

The *Air Pump* for a land engine generally requires to be larger in proportion to the cylinder than the air pump for a marine engine, on account of having frequently to condense with water at a higher temperature; hence, when the stroke of the bucket is half the stroke of the piston, multiply the cylinder's diameter in inches by ·67, and the product is the diameter of air pump. —Again, multiply the diameter of the cylinder of a marine engine, in inches, by ·575, *or* $\frac{23}{40}$, and the product is the diameter of air pump.

EXAMPLE.—What diameter of air pump is requisite for an engine whose cylinder is 28 inches diameter?

Here 28 × ·67 × 18·76 inches diameter. = *Ans.*

When the stroke of the bucket is either more or less than half the stroke of the piston, the pump's diameter will then be obtained by the following

RULE.—Square the given diameter, multiply by the length, and divide by the length proposed, extract the square root, and the product will be the diameter.

Or, multiply the given diameter by the square root of the quotient of the first length by the altered length.

EXAMPLE.—Suppose an engine with a 4-feet stroke required an air pump 26 inches diameter with a 2-feet stroke, but necessity requires it to be 6 inches nearer the end of the beam, what must be the diameter of air pump, the beam being 11 feet long?

Here radius of beam = 66 inches.

Then 4 feet : 2 feet :: 66 inches : 33 inches, first distance of the air pump.

And 33 + 6 = 39 inches, the altered distance of the air pump.

And 66 : 48 :: 39 : 28·36 inches, length of stroke.

And $\sqrt{\frac{26^2 \times 24}{28{\cdot}36}} = 26\sqrt{\frac{24}{28{\cdot}36}} = 260\sqrt{\frac{24}{2836}}$

$$= 260 \sqrt{\frac{6}{709}} = \frac{260 \sqrt{(6 \times 709)}}{709} = \frac{260 \sqrt{4254}}{709} =$$

$$\frac{260 \times 65{\cdot}22}{709} = \frac{16957{\cdot}2}{709} = 24 \text{ inches, diameter of pump,}$$

nearly. = *Ans.*

The *Condenser* ought to be a little more in capacity than the air pump; but in the case of marine engines, where the bottom of the condenser and bottom of the cylinder are nearly on a level, care must be taken to make the passage between the valves and condenser large enough to contain the condensing water required for one stroke of the piston, besides leaving a proper communication, otherwise the connexion between the cylinder and condenser will be cut off by water of nearly 100° of heat, on account of the cylinder being twice filled with steam for each effective stroke of the air pump.

One-fourth of the area of air pump will give the area of foot and discharging valves; thus, 24 inches diameter gives 452·39 inches area, one-fourth of which = 113·0975 inches, area of valves.

The piston rod is about $\frac{1}{10}$ of the cylinder's diameter; the air pump rod in the same ratio, unless it be made of copper, and then it may be about $\frac{1}{8}$ of the pump's diameter.

THE BEAM.

When a beam is applied to an engine its length ought not to be less than three times the length of the stroke, and its breadth half the stroke, or in high pressure engines, $\frac{2}{5}$ of the stroke; also its best form is a parabola.

To find the thickness of a beam when its length and breadth, together with the diameter of the cylinder, are given.

RULE.—Multiply the whole pressure of steam on the piston, in *lbs.*, by half the length of the beam in feet, and divide the product by 70 times the square of the breadth, in inches, and the quotient will be the thickness in inches, nearly.

EXAMPLE.—What thickness of beam is requisite for an engine whose cylinder is 25 inches diameter, the length of the beam being 15 feet, length of stroke 5 feet, and the effective pressure on each square inch of the piston = 15 *lbs.?*

Here area of piston = $25^2 \times \cdot 7854 = 490 \cdot 875$ square inches.

And length of stroke = 60 inches, which divided by 2, gives 30 inches, the breadth of the beam.

Whence $\frac{490 \cdot 875 \times 15 \times 7 \cdot 5}{30^2 \times 70} = \frac{490 \cdot 875 \times 15 \times 15}{900 \times 140}$

$= \frac{490 \cdot 875}{20 \times 28} = \frac{14 \cdot 025}{16} = \cdot 8765625$, or $\frac{7}{8}$ of an inch in thickness, nearly. = *Ans.*

To find the versed sine of the arc described by the beam of an engine.

RULE.—Divide the square of half the length of the stroke, in inches, by the length of the beam, also in inches, and the quotient is the versed sine.

EXAMPLE.—Required the versed sine of the arc described by an engine beam 12 feet in length, the chord of the arc, or length of the stroke, being 4 feet.

Here $\frac{24^2}{144} = \frac{24^2}{12^2} = 2^2 = 4$ inches, the versed sine. = *Ans.*

NOTE.—When the beam is not equal lengths at each end from the centre on which it vibrates, the length is then to be taken equal to twice the radius of that end of which the versed sine is required.

THE PARALLEL MOTION.

The beam being given, to find the length of the radius rods.

RULE.—Divide the square of the distance between A and B, on the beam, by the distance between B and C, and the quotient is the length of the radius rod $d\,x$.

TABLE OF PARALLEL MOTIONS.

FIG. 1st A motion that is generally applied to land Engines &c.

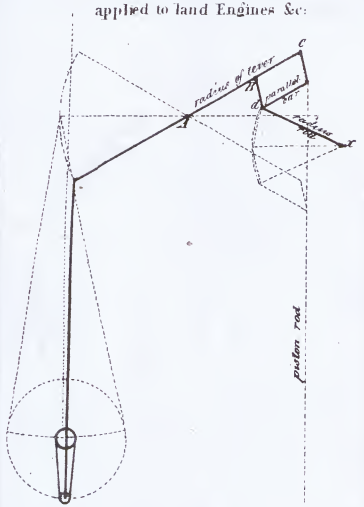


FIG. 2nd A motion that is applicable to either land or marine Engines

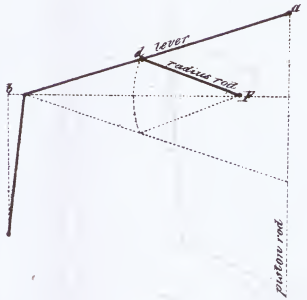


FIG. 3rd A motion that is chiefly used in marine Engines.

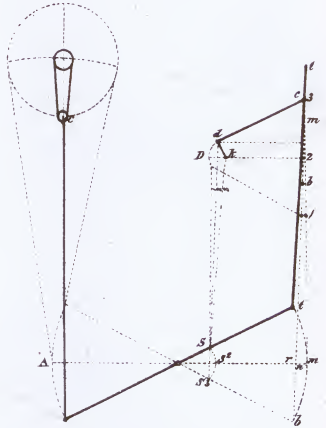


FIG. 4th A motion for an Engine with two Cylinders, combining the principle of High & Low pressure.

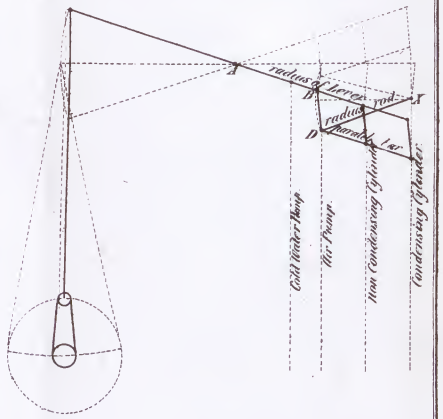


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FIG. 1, EXAMPLE.—Suppose a beam 12 feet long, and the stud for the back links 39 inches from the centre, required the length of radius rods.

Here radius of beam = 72 inches, and 72 − 39 = 33 *in.*; then $\frac{39^2}{33} = \frac{39 \times 13}{11} = \frac{507}{11} = 46{\cdot}09$ inches. = *Ans.*

NOTE.—The length of the front and back links equal half the length of the stroke.

FIG. 2, EXAMPLE.—Suppose $b\ d = 32\frac{1}{4}$, and $d\ a = 35\frac{1}{4}$, to find d F.

Here $\frac{32{\cdot}25^2}{35{\cdot}25} = \frac{129^2}{564} = 29{\cdot}5$ inches, nearly. = *Ans.*

FIG. 3.—As the calculation of this motion is rather tedious, on account of the various angles formed by the side rods, it is considered better to lay it down in the following geometrical form:—

Upon the line A m, with the radius of the beam, describe the arc $b\ m\ t$; from m, with half the length of stroke, cut the arc in b and t, draw the line $b\ t$ and $r\ m$ equal the versed sine described by the beam; bisect $r\ m$ in n, and erect a perpendicular line for the centre of the cylinder. Again, from $b\ m\ t$, with the length of the side rods, cut the perpendicular line; at the bottom, middle, and top stroke of the cross-head, draw the lines $b\ b$, $m\ m$, $t\ t$; from the end of the cross-head, or top of the side rods, with any convenient distance, set off the pin or stud in the side rod for the end of the parallel bar 1, 2, 3, from which, with the distance $s\ t$, describe arcs at d D d; draw the lines d 1, D 2, &c. Then the length of the crank may be found either by the seventh problem in Geometry, *page* 31, or the eleventh problem in Mensuration, *page* 52.

THE CONNECTING ROD.

The length of connecting rod is in general three times the length of stroke, which determines the per-

pendicular distance between the centre of the beam and centre of fly-wheel shaft. *Or*, if the engine is erected, the length of connecting rod is the perpendicular distance between the centre of the fly-wheel shaft, and centre of the beam.

THE FLY-WHEEL.

To find the weight of the rim or ring of a fly-wheel proper for a steam engine.

RULE.—Multiply the constant number, 1368, by the number of horses' power that the engine is equal to; divide the product by the diameter of the wheel, in feet, multiplied by the number of revolutions per minute; and the quotient is the weight of the ring in *cwts.*, nearly.

EXAMPLE.—Required the weight of the rim of a fly-wheel proper for an engine of 20 horses' power, the wheel to be 16 feet diameter, and make 21 revolutions per minute.

$$\frac{1368 \times 20}{16 \times 21} = \frac{114 \times 5}{7} = \frac{570}{7} = 81{\cdot}4 \text{ } cwt., \text{ nearly.}$$

$= Ans.$

NOTE.—The fly-wheel of an engine for a corn or flour mill ought to be of such a diameter that the velocity of the periphery of the wheel may exceed the velocity of the periphery of the stones, to prevent, as much as possible, any tendency to back lash, as it is termed.

The necessary weight and diameter of the wheel being found, suppose a breadth of rim, and the thickness to make the weight in cast iron will be found by the following

RULE.—Multiply the required weight in *lbs.* by 4·841, and divide the result by the product of the sum and difference of the diameters, in inches, and the quotient is the thickness of the ring in inches.

EXAMPLE.—What thickness must a ring be to equal 81·4 *cwts.*, when the outer diameter is 16 feet, and the inner diameter 14 feet 8 inches ?

Here 81·4 *cwts.* = 9116·8 *lbs.*

Then, $\frac{9116{\cdot}8 \times 4{\cdot}841}{(192+176) \times (192-176)} = \frac{9116{\cdot}8 \times 4{\cdot}841}{368 \times 16}$

$= \frac{284{\cdot}9 \times 4{\cdot}841}{184} = \frac{1379{\cdot}2}{184} = 7{\cdot}496$ inches, *nearly.*

= *Ans.*

And if the ring is to be of a cylindrical form, find the diameter of a circle (by Problem XIII. *p.* 55, in Mensuration) having the same area as the cross-section of the ring found.

Thus, suppose the ring, in the last example, be required to be cylindrical,—Required its cross-sectional diameter to equal 81·4 *cwts.*, the diameter of the wheel being 16 feet.

Here 7·496 × 8 = 59·968 inches cross-sectional area of the ring found.

And $\sqrt{\frac{59{\cdot}968 \times 452}{355}} = \sqrt{\frac{27105{\cdot}536}{355}} = \sqrt{76{\cdot}35}$

= 8·74 inches diameter, *nearly.* = *Ans.*

Or, as an approximation, multiply the required weight in *lbs.*, by 1·62 ; divide the product by the diameter of the wheel, in inches, and the square root of the quotient will be the diameter of the cross-section of the ring, in inches, nearly.

Thus $\sqrt{\left(\frac{9116{\cdot}8 \times 1{\cdot}62}{16 \times 12}\right)} = \sqrt{(284{\cdot}9 \times {\cdot}27)} =$

$\sqrt{76{\cdot}923} = 8{\cdot}78$ inches. = *Ans. as before, nearly.*

Sometimes (for various reasons) it is necessary to have the fly-wheel upon a second mover ; for instance,

there is a 6-horse engine making 50 revolutions per minute, having a fly-wheel of 7 *ft.* diameter, and 9 *cwt.*, but, by the rule, it ought to be 23·46 *cwt.* Now, a larger wheel cannot be got in, but the same may be put upon a second mover,—required the velocity that will increase its momentum equal to 23·46 *cwt.* on the first mover.

Here 7 feet (diameter) × 3·1416 = 21·9912 feet circumference, and 21·9912 × 50 revolutions = 1099·56 feet velocity.

Then, as $\overset{Cwt.}{9} : \overset{Cwt.}{23{\cdot}46} :: \overset{Velocity.}{1099{\cdot}56} : \overset{Velocity.}{2866{\cdot}1864}$,

and 2866·1864 ÷ 21·9912 = 130 revolutions per minute, nearly. = *Ans.*

To find the centrifugal force of a fly-wheel.

Rule.—Multiply ·6132* by the diameter of the wheel in feet and its weight, and divide the product by the square of the time of one revolution; the quotient will be the centrifugal force.

Example.—Required the centrifugal force of a fly-wheel 15 feet diameter, and making 40 revolutions per minute, the weight of the ring being 3 tons.

Here 60 ÷ 40 = 1·5, time of one revolution.

And $\frac{\cdot6132 \times 15 \times 3}{1{\cdot}5^2} = \frac{\cdot6132}{\cdot05} = \frac{61{\cdot}32}{5} = 12{\cdot}264$

tons, the centrifugal force. = *Ans.*

The centre of percussion in a fly-wheel, or wheels in general, is $\frac{3}{4}$ distant from the centre of suspension nearly.

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* This number is $= \frac{3{\cdot}1416^2}{16{\cdot}095} = \frac{24}{\text{length of seconds pendulum}} = \frac{24}{39{\cdot}139}$ (*see page* 101).

NOTE.—The centrifugal force is that power or tendency which all revolving bodies have to burst, or fly asunder in a direct line.

And the centre of percussion in a revolving body is that point where the whole force or motion is collected, or that point which would strike any obstacle with the greatest effect.

THE GOVERNOR OR REGULATOR.

The length of pendulums given, to find the number of revolutions per minute.

RULE.—Divide 375 (*see page* 101) by the square root of the pendulum's length, and half the quotient will be the velocity required.

EXAMPLE.—What number of revolutions ought a governor to make per minute whose pendulums are 24 inches long?

Here $\frac{375}{\sqrt{24}} = \frac{375 \times \sqrt{24}}{24} = \frac{3000 \times \sqrt{24}}{192} =$

$\frac{1000}{64} \times 2 \times \sqrt{6} = \frac{1000}{32} \times \sqrt{6} = \frac{1000}{32} \times 2{\cdot}449 =$

$\frac{2449}{32} = 76$, then $76 \div 2 = 38$ revolutions per minute.

$=$ *Ans.*

The revolutions per minute of a governor given, to find the length of pendulums.

RULE.—Divide 375 by twice the number of revolutions per minute, and the square of the quotient will be the length required.

EXAMPLE.—When the velocity of a governor is 38 revolutions per minute, what ought to be the length of pendulums?

Here $38 \times 2 = 76$, and $\left(\frac{375}{76}\right)^2 = 4{\cdot}93^2 = 24{\cdot}3049$ inches. $=$ *Ans.*

OF HIGH-PRESSURE STEAM ENGINES.

High-pressure engines, in general (if in good condition), will work when the force of the steam is about 4 *lbs.* per circular inch,—that is, 4 *lbs.* on each circular inch of the piston will overcome the resistance and friction of the engine itself, divested of machinery, &c. Hence the rule.

1. From the pressure in *lbs.* on each circular inch of the boiler deduct 4 *lbs.;* multiply the remainder by the square of the cylinder's diameter in inches, and by the velocity of the piston in feet per minute; divide the product by 33000, and the quotient will be the force of the engine expressed in horses' power.

EXAMPLE.—Suppose a cylinder 8 inches diameter, stroke 2 feet, making 45 revolutions per minute, or 180 feet, and steam 23·5 *lbs.* per circular inch, required the power.

Here $\frac{(23{\cdot}5 - 4) \times 8^2 \times 180}{33000} = \frac{19{\cdot}5 \times 64 \times 6}{1100} =$

$\frac{7488}{1100} = 6{\cdot}8$ horses' power, nearly. = *Ans.*

2. Multiply 33000 by the number of horses' power required, and divide the product by the velocity of the piston in feet per minute, multiply by the force of the steam in *lbs.* on each circular inch of the boiler, minus 4 *lbs.*, and the square root of the quotient is the cylinder's diameter in inches.

EXAMPLE.—Required the diameter of the cylinder for an engine of 6·8 horses' power, when the stroke is 2 feet, and making 45 strokes per minute, the force of the steam being 23·5 *lbs.* per circular inch.

$$\text{Here } \sqrt{\frac{33000 \times 6{\cdot}8}{180 \times (23{\cdot}5 - 4)}} = \sqrt{\frac{1100 \times 6{\cdot}8}{6 \times 19{\cdot}5}} = \sqrt{\frac{7480}{117}} = \sqrt{64} = 8 \text{ inches diameter.} = \textit{Ans.}$$

NOTE.—There is always a resistance of steam on the piston of a high-pressure or non-condensing engine equal to the pressure of the atmosphere; but this cannot be taken into account, unless we also take into account the pressure of the atmosphere upon the boiler.

MISCELLANIES.

Approximate rules for finding the weight of round, square, and rectangular beams, bars, &c., of cast and wrought iron.

Rule 1. *For cylinders.*—Multiply the square of the diameter in inches by the length in feet, and by 2·65 for wrought iron, or 2·48 for cast iron, and the product will be the weight in pounds avoirdupois, *nearly*.

2, *or generally.*—Multiply the area of the cross section in inches by the length in feet, and by 3·38 for wrought iron, or 3·16 for cast iron, and the product will be the weight in pounds avoirdupois, *nearly*.

Example 1.—Required the weight of a round bar of wrought iron 14 feet long and $2\frac{1}{2}$ inches diameter.

Here $2{\cdot}5^2 \times 14 \times 2{\cdot}65$ *lbs.* $= 232$ *lbs.* $=$ *Ans.*

Or, if the area of the cross section, $2{\cdot}5^2 \times {\cdot}7854 = 4{\cdot}91$, had been given, then by the second or general rule $4{\cdot}91 \times 14 \times 3{\cdot}38$ *lbs.* $= 232$ *lbs.* $=$ *Ans. as before.*

Example 2.—The length of a piece of cast iron is $9\frac{1}{2}$ feet, its breadth 7 inches, and thickness $2\frac{1}{4}$, required its weight.

Here $9\frac{1}{2} \times 7 \times 2\frac{1}{4} \times 3{\cdot}16 = 472{\cdot}815$ *lbs.* $=$ *Ans.*

The dimensions of a cast iron ring being given, to find its weight, nearly.

Rule.—Multiply the breadth of the ring added to the inner diameter by ·0074, and that again by the breadth and by the thickness, and the product will be its weight in *cwts.*, *nearly*.

Example.—Required the weight of a ring whose dimensions are 8 feet 4 inches interior diameter, 5 inches broad and 4 inches thick.

Here 8 ft. 4 in. $=$ $\overset{\text{Inches.}}{100}$; then $(100 + 5) \times 5 \times 4 \times \cdot0074 = 105 \times 20 \times \cdot0074 = 15\cdot54$ *cwts., nearly.* $=$ *Ans.*

To find the weight of any cast iron ball whose diameter is given.

Rule.—Multiply the cube of the diameter in inches by ·1377, and the product will be the weight in avoirdupois pounds, nearly.

Example.—Required the weight of a ball 7 inches diameter.

Here $7^3 \times \cdot1377 = 343 \times \cdot1377 = 47\cdot2311$ *lbs.* $=$ *Ans.*

To find the diameter of a cast iron ball when the weight is given.

Rule.—Multiply the cube root of the weight in pounds by 1·9365, and the product will be the diameter in inches, *nearly.*

Example.—Required the diameter of a ball that will weigh 64 pounds.

Here $\sqrt[3]{\ } 64 \times 1\cdot9365 = 4 \times 1\cdot9365 = 7\cdot746$ inches diameter. $=$ *Ans.*

TABLE

Containing the weight of a square foot of copper and lead, in lbs. avoirdupois, from $\frac{1}{32}$ to $\frac{1}{2}$ an inch in thickness, advancing by $\frac{1}{32}$.

Thickness.	Copper.	Lead.
$\frac{1}{32}$	1·45	1·85
$\frac{1}{16}$	2·90	3·70
$\frac{3}{32}$	4·35	5·54
$\frac{1}{8}$	5·80	7·39
$\frac{1}{8} + \frac{1}{32}$	7·26	9·24
$\frac{1}{8} + \frac{1}{16}$	8·71	11·08
$\frac{1}{8} + \frac{3}{32}$	10·16	12·93
$\frac{1}{4}$	11·61	14·77
$\frac{1}{4} + \frac{1}{32}$	13·07	16·62
$\frac{1}{4} + \frac{1}{16}$	14·52	18·47
$\frac{1}{4} + \frac{3}{32}$	15·97	20·31
$\frac{3}{8}$	17·42	22·16
$\frac{3}{8} + \frac{1}{32}$	18·87	24·00
$\frac{3}{8} + \frac{1}{16}$	20·32	25·85
$\frac{3}{8} + \frac{3}{32}$	21·77	27·70
$\frac{1}{2}$	23·22	29·55

TABLE

Of the weight of a square foot of sheet iron in lbs. avoirdupois, the thickness being the number on the wire gauge.—No. 1 *is* $\frac{5}{16}$ *of an inch; No.* 4, $\frac{1}{4}$; *No.* 11, $\frac{1}{8}$, *&c.*

No. on wire gauge ...	1	2	3	4	5	6	7	8	9	10	11
Pounds avoir. ...	12·5	12	11	10	9	8	7·5	7	6	5·68	5
No. on wire gauge ...	12	13	14	15	16	17	18	19	20	21	22
Pounds avoir. ...	4·62	4·31	4	3·95	3	2·5	2·18	1·93	1·62	1·5	1·37

TABLE

Of the weight of a square foot of boiler plate iron, from $\frac{1}{8}$ *to* 1 *inch thick, in lbs. avoirdupois.*

$\frac{1}{8}$	$\frac{3}{16}$	$\frac{1}{4}$	$\frac{5}{16}$	$\frac{3}{8}$	$\frac{7}{16}$	$\frac{1}{2}$	$\frac{9}{16}$	$\frac{5}{8}$	$\frac{11}{16}$	$\frac{3}{4}$	$\frac{13}{16}$	$\frac{7}{8}$	$\frac{15}{16}$	1 in.
5	7·5	10	12·5	15	17 5	20	22·5	25	27·5	30	32·5	35	37·5	40

TABLE

Of the weight of solid cylinders of cast iron, 12 *inches long, in lbs. avoirdupois.*

Dmr. Inch.	Weight, in *lbs.*	Dmr. Inch.	Weight, in *lbs.*	Dmr. Inch.	Weight, in *lbs.*	Dmr. Inch.	Weight, in *lbs.*	Dmr. Inch.	Weight, in *lbs.*
$\frac{3}{4}$	1·394	$2\frac{1}{8}$	11·193	$3\frac{1}{2}$	30·364	$5\frac{3}{4}$	81·953	9	200·776
$\frac{7}{8}$	1·898	$2\frac{1}{4}$	12·548	$3\frac{5}{8}$	32·572	6	89·234	$9\frac{1}{2}$	223·705
1 *in.*	2·479	$2\frac{3}{8}$	13·981	$3\frac{3}{4}$	34·857	$6\frac{1}{4}$	96·825	10	247·872
$1\frac{1}{8}$	3·137	$2\frac{1}{2}$	15·492	$3\frac{7}{8}$	37·219	$6\frac{1}{2}$	104·726	$10\frac{1}{2}$	273·279
$1\frac{1}{4}$	3·873	$2\frac{5}{8}$	17·080	4	39·660	$6\frac{3}{4}$	112·936	11	299·925
$1\frac{3}{8}$	4·686	$2\frac{3}{4}$	18·745	$4\frac{1}{4}$	44·772	7	121·457	$11\frac{1}{2}$	327·811
$1\frac{1}{2}$	5·577	$2\frac{7}{8}$	20·488	$4\frac{1}{2}$	50·194	$7\frac{1}{4}$	130·288	12	356·935
$1\frac{5}{8}$	6·545	3	22·308	$4\frac{3}{4}$	55·926	$7\frac{1}{2}$	139·428	13	418·903
$1\frac{3}{4}$	7·591	$3\frac{1}{8}$	24·206	5	61·968	$7\frac{3}{4}$	148·878	14	485·829
$1\frac{7}{8}$	8·714	$3\frac{1}{4}$	26·181	$5\frac{1}{4}$	68·320	8	158·638	15	557·712
2	9·915	$3\frac{3}{8}$	28·234	$5\frac{1}{2}$	74·981	$8\frac{1}{2}$	179·087	16	634·552

Cubic inches of cast iron multiplied by ·263 = *lbs.* avoirdupois.

Circular inches of cast iron multiplied by ·2066 = *lbs.* avoirdupois.

TABLE

For finding the weight of malleable iron, copper, and lead pipes, 12 *inches long, of various thicknesses, and any diameter required.*

Thickness.	Mall. Iron.	Copper.	Lead.
$\frac{1}{32}$ of an *in.*	·104	·1210	·1539
$\frac{1}{16}$	·207	·2419	·3078
$\frac{3}{32}$	·3108	·3629	·4616
$\frac{1}{8}$	·414	·4839	·6155
$\frac{1}{8} + \frac{1}{32}$	·518	·6049	·7694
$\frac{1}{8} + \frac{1}{16}$	·621	·7258	·9232
$\frac{1}{8} + \frac{3}{32}$	·725	·8468	1·0771
$\frac{1}{4}$	·828	·9678	1·2310

Rule.—Multiply the circumference of the pipe in inches by the numbers opposite the thickness required, and by the length in feet; the product will be the weight in avoirdupois *lbs. nearly.*

Example.—Required the weight of a copper pipe 12 feet long, 15 inches in circumference, $\frac{1}{8}$ and $\frac{1}{16}$ of an inch in thickness.

Here ·7258 *lbs.* × 15 × 12 = 130·644 *lbs. nearly.* = *Ans.*

TABLE

Containing the weight of wrought iron bars 12 *inches long, in lbs. avoirdupois.*

Inch.	Round.	Square.	Inch.	Round.	Square.
$\frac{1}{4}$	·166	·211	$2\frac{1}{2}$	16·59	21·13
$\frac{3}{8}$	·373	·475	$2\frac{5}{8}$	18·30	23·29
$\frac{1}{2}$	·664	·845	$2\frac{3}{4}$	20·08	25·56
$\frac{5}{8}$	1·04	1·32	$2\frac{7}{8}$	21·94	27·94
$\frac{3}{4}$	1·50	1·90	3	23·96	30·42
$\frac{7}{8}$	2·03	2·59	$3\frac{1}{4}$	28·04	35·70
1	2·65	3·38	$3\frac{1}{2}$	32·52	41·41
$1\frac{1}{8}$	3·36	4·28	$3\frac{3}{4}$	37·34	47·53
$1\frac{1}{4}$	4·15	5·28	4	42·48	54·08
$1\frac{3}{8}$	5·02	6·39	$4\frac{1}{4}$	47·96	61·05
$1\frac{1}{2}$	5·99	7·60	$4\frac{1}{2}$	53·77	68·45
$1\frac{5}{8}$	7·01	8·92	$4\frac{3}{4}$	59·91	76·27
$1\frac{3}{4}$	8·13	10·35	5	66·38	84·51
$1\frac{7}{8}$	9·33	11·88	$5\frac{1}{4}$	73·18	93·17
2	10·62	13·52	$5\frac{1}{2}$	80·32	102·25
$2\frac{1}{8}$	11·99	15·26	$5\frac{3}{4}$	87·78	111·76
$2\frac{1}{4}$	13 44	17·11	6	95·58	121·69
$2\frac{3}{8}$	14·98	19·07	7	130·10	165·63

TABLE

Of the proportional dimensions of 6 *sided nuts for bolts, from* $\frac{1}{4}$ *to* $2\frac{1}{2}$ *inches diameter.*

Diameter of bolts	$\frac{1}{4}$	$\frac{3}{8}$	$\frac{1}{2}$	$\frac{5}{8}$	$\frac{3}{4}$	$\frac{7}{8}$	1	$1\frac{1}{8}$	$1\frac{1}{4}$
Breadth of nuts..	$\frac{11}{16}$	$\frac{13}{16}$	1	$1\frac{3}{16}$	$1\frac{3}{8}$	$1\frac{9}{16}$	$1\frac{3}{4}$	$1\frac{15}{16}$	$2\frac{1}{8}$
Breadth over the angles....	$\frac{13}{16}$	$\frac{15}{16}$	$1\frac{1}{8}$	$1\frac{3}{8}$	$1\frac{8}{16}$	$1\frac{13}{16}$	2	$2\frac{1}{4}$	$2\frac{7}{16}$
Thickness	$\frac{5}{16}$	$\frac{7}{16}$	$\frac{9}{16}$	$\frac{3}{4}$	$\frac{7}{8}$	1	$1\frac{1}{8}$	$1\frac{1}{4}$	$1\frac{7}{16}$
Diameter of bolts	$1\frac{3}{8}$	$1\frac{1}{2}$	$1\frac{5}{8}$	$1\frac{3}{4}$	$1\frac{7}{8}$	2	$2\frac{1}{4}$	$2\frac{1}{2}$	
Breadth of nuts..	$2\frac{5}{16}$	$2\frac{1}{2}$	$2\frac{11}{16}$	$2\frac{7}{8}$	$3\frac{1}{16}$	$3\frac{1}{4}$	$3\frac{5}{8}$	4	
Breadth over the angles....	$2\frac{1}{16}$	$2\frac{7}{8}$	$3\frac{1}{8}$	$3\frac{5}{16}$	$3\frac{1}{2}$	$3\frac{3}{4}$	$4\frac{3}{16}$	$4\frac{5}{8}$	
Thickness	$1\frac{9}{16}$	$1\frac{11}{16}$	$1\frac{13}{16}$	2	$2\frac{1}{8}$	$2\frac{1}{4}$	$2\frac{1}{2}$	$2\frac{3}{4}$	

TABLE

Of the weight of flat bar iron, 12 inches long, in lbs. avoirdupois.

Thickness.	1/8	3/16	1/4	3/8	1/2	5/8	3/4	7/8	1 inch.
Breadth, in inches. ½	·21	·31	·42	·63					
¾	·32	·48	·63	·95	1·27	1·58			
1	·42	·63	·84	1·26	1·69	2·11	2·53	2·96	
1¼	·52	·79	1·05	1·58	2·11	2·64	3·16	3·70	4·22
1⅜	·58	·87	1·16	1·74	2·32	2·90	3·48	4·06	4·64
1½	·63	·95	1·27	1·90	2·53	3·17	3·80	4·44	5·07
1¾	·74	1·11	1·48	2·21	2·95	3·70	4·43	5·43	5·91
2	·84	1·27	1·69	2·53	3·38	4·22	5·07	5·92	6·76
2¼	·95	1·42	1·90	2·85	3·80	4·75	5·70	6·65	7·60
2½	1·06	1·58	2·11	3·17	4·22	5·28	6·33	7·40	8·45
2¾	1·16	1·74	2·32	3·49	4·64	5·81	6·97	8·13	9·29
3	1·27	1·90	2·53	3·80	5·07	6·34	7·60	8·87	10·14
3¼	1·37	2·06	2·74	4·12	5·49	6·86	8·24	10·09	10·98
3½	1·48	2·22	2·95	4·43	5·91	7·39	8·87	10·87	11·83
3¾	1·58	2·38	3·17	4·75	6·34	7·92	9·51	11·65	12·68
4	1·69	2·53	3·38	5 07	6·76	8·45	10·14	11·83	13·52
4½	1·90	2·85	3·80	5·70	7·60	9·50	11·41	13·31	15·21
5	2·11	3·17	4·22	6·34	8·45	10·56	12·67	14·79	16·90
6	2·53	3·80	5·07	7·69	10·14	12·67	15·21	17·75	20·28

Weight of a copper rod 12 inches long and 1 inch diameter = 3·039 *lbs.*

Weight of a brass rod 12 inches long and 1 inch diameter = 2·86 *lbs.*

TABLE

Of the specific gravity of water at different temperatures, that at 62° being taken as unity.

70° F.	·99913	52° F.	1·00076
68	·99936	50	1·00087
66	·99958	48	1·00095
64	·99980	46	1·00102
62	1·	44	1·00107
58	1·00035	42	1·00111
56	1·00050	40	1·00113
54	1·00064	38	1·00115

The difference of temperatures between 62° and 38°, where water attains its greatest density, will vary the bulk of a gallon rather less than the third of a cubic inch.

TABLE

Of the weight of cast iron pipes 12 *inches long, in lbs. avoirdupois.*

Diam. of bore in inches.	THICKNESS IN INCHES.							
	⅜	½	⅝	¾	⅞	1 *in.*	1⅛	1¼
	lbs.	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*
1½	6·9	9·9	..	..	..	..	..	..
2	8·8	12·4	16·3	20·4	..	..	..	..
2½	10·7	14·9	19·4	24·1	..	..	..	..
3	12·5	17·4	22·4	27·8	33·6	39·7	46·0	..
3½	14·4	19·9	25·5	31·5	37·9	44·7	51·6	..
4	16·2	22·3	28·6	35·2	42·8	49·6	57·1	65·1
4½	18·1	24 8	31·7	38·9	46·7	54·6	62·7	71·2
5	20·0	27·3	34·9	42·7	51·0	59·5	68·3	77·4
5½	21·9	29·8	38·0	46·4	55·3	64·5	73·9	83·6
6	23·7	32·2	41·1	50·1	59·6	69·4	79·4	89·8
6½	25·6	34·7	44·2	53·8	63 9	74·4	85·0	96·0
7	27·4	37·2	47·3	57·5	68·3	79·3	90·6	102·2
7½	29·3	39·7	40·4	61·2	72·6	84·3	96·2	108·4
8	31·1	42·2	53·5	65·0	77·0	89·3	101·8	114·6
8½	33·0	44·7	56·6	68·7	81·3	94·3	107·4	120·8
9	34·9	47·1	59·6	72·4	85·7	99·2	112·9	127·0
9½	36·8	49·6	62·7	75·1	89·0	104·2	118·5	133·2
10	38·6	52·1	65·8	79·9	94·3	109·1	124·1	139·4
10½	..	54 6	68·9	82·6	98·6	114·1	129·7	145 6
11	..	57·0	72·0	87·3	103·0	119·0	135·2	151·8
11½	..	59·6	75·1	90·0	107·3	124·0	140·8	158 0
12	..	62 0	78·2	94·7	111·7	128·9	146·4	164·2
13	..	..	84·4	102·2	120·4	138·8	157·5	176·6
14	..	..	90·6	109·6	129·0	148·8	168·7	189·0
15	..	..	96·8	117·0	137·7	158·7	179·8	201·4
16	..	..	..	124·5	146·4	168·6	181·0	213·8
17	..	..	..	131·9	155·1	178·5	202·1	224·2
18	..	..	..	139·4	163·7	188·4	213·3	238·5
19	..	..	..	..	172·4	198·3	224·4	250·9
20	..	..	..	..	181·1	208·2	235·6	263·3
21	..	..	..	..	..	218·2	246·7	275·7
22	..	..	..	..	..	228·1	257·9	288·1
23	..	..	..	..	..	238·0	269·0	300·5
24	..	..	..	..	..	247·9	280 2	312·9

NOTE.—The first column is the width of the pipes, expressed in inches and parts of an inch; and the remaining columns are the weights of the pipes, under the different thicknesses in which they are placed.

N.B.—Two flanges are generally reckoned equal to one foot of pipe.

TABLE

Of the weight of cast iron balls in lbs. avoirdupois, from 1 *to* 12 *inches diameter, and advancing by an eighth.*

Inches.	*lbs.* and parts.	Inches.	*lbs.* and parts.	Inches.	*lbs.* and parts.
1	·14	4¾	14·76	8½	84·57
1⅛	·20	4⅞	15·95	8⅝	88·35
1¼	·27	5	17·21	8¾	92·25
1⅜	·36	5⅛	18·54	8⅞	96·26
1½	·47	5¼	19·93	9	100·39
1⅝	·59	5⅜	21·38	9⅛	104·63
1¾	·74	5½	22·91	9¼	108·99
1⅞	·91	5⅝	24·51	9⅜	113·47
2	1·10	5¾	26·18	9½	118·06
2⅛	1·32	5⅞	27·92	9⅝	122·77
2¼	1·57	6	29·74	9¾	127·63
2⅜	1·84	6⅛	31·64	9⅞	132·60
2½	2·15	6¼	33·62	10	137·70
2⅝	2·49	6⅜	35·68	10⅛	142·93
2¾	2·86	6½	37·81	10¼	148·29
2⅞	3·27	6⅝	40·04	10⅜	153·78
3	3·72	6¾	42·35	10½	159·40
3⅛	4·20	6⅞	44·75	10⅝	165·16
3¼	4 73	7	47·23	10¾	171·06
3⅜	5·29	7⅛	49·80	10⅞	177·10
3½	5·90	7¼	52·47	11	183·28
3⅝	6·56	7⅜	55·23	11⅛	189·60
3¾	7·26	7½	58·09	11¼	196·06
3⅞	8·01	7⅝	60·04	11⅜	202·67
4	8 81	7¾	64·09	11½	209·42
4⅛	9·67	7⅞	67·24	11⅝	216·33
4¼	10 57	8	70·50	11¾	223·38
4⅜	11·53	8⅛	73·86	11⅞	230·58
4½	12·55	8¼	77·32	12	237·94
4⅝	13·62	8⅜	80·89		

TABLE

Of the weight of a square foot of millboard in lbs. avoirdupois.

Thickness, in inches..	⅛	3/16	¼	5/16	⅜
Weight, in *lbs.*	·688	1·032	1·376	1·72	2·064

TABLE

Containing some of the properties of various bodies.

Names of bodies.	Melting and boiling points.	Contracts in cooling, in parts of an inch, for each foot in length.	Expands in heating from 32 to 212 deg. of Fahrenheit, the length being 1·00000	Power of conducting heat.
Cast iron melts	17977°	·124	·00111	1·2
Wrought iron welding hot	12780	·137	·00122	1·1
Copper melts ..	4587	·193	·00172	1·0
Brass melts ..	3807	·210	·00187	1·0
Steel red hot ..	1077	·133	·00118	
Zinc melts	700	·329	·00294	
Mercury boils..	660		·01851	
Lead melts	594	·319	·00286	2·5
Bismuth melts .	476	·156	·00139	
Tin melts	442	·278	·00248	1·7
Water boils ..	212		·04002	

TABLE

Showing the expansion of water by heat.

Temperature.	Expansion.	Temperature.	Expansion.
12° F.	1·00236	122° F.	1·01116
22	1·00090	132	1·01367
32	1·00022	142	1·01638
42	1·00000	152	1·01934
52	1·00021	162	1·02245
62	1·00083	172	1·02575
72	1·00180	182	1·02916
82	1·00312	192	1·03265
92	1·00477	202	1·03634
102	1·00672	212	1·04012
112	1·00880		

Proportions of cement for cast iron.

In mixing cement for cast iron, put one ounce of sal ammoniac to each hundred weight of borings, and use it without allowing it to heat. Multiply the length of any joint in feet by the breadth in inches, by the thickness in eighths, and by ·3; the product will be the weight of dry borings, in *lbs.* avoirdupois, required to make cement to fill that joint *nearly.*

TABLE

Of boiling points of water holding various proportions of salt in solution.

	Parts of Salt.	Degrees of Fahrenheit.	Degrees of Reaumur.	Degrees of Centigrade.
Saturated solution	36·37	226·6	86 5	108·1
,,	33·34	224·9	85·7	107·2
,,	30·30	223·7	85·2	106·5
,,	27·28	222·5	84·7	105·8
,,	24·25	221·4	84·2	105·2
,,	21·22	220·2	83·7	104·6
,,	18·18	219·0	83·1	103·9
,,	15·15	217·9	82·6	103·3
,,	12·12	216·7	82·1	102·6
,,	9·09	215·5	81·5	101·9
,,	6·06	214·4	81·1	101·3
Sea water	3·03	213·2	80·5	100·7
Common water ..	0·00	212·0	80·0	100·0

To reduce any number of degrees of temperature on Fahrenheit's scale to the number of degrees of an equal temperature on Reaumur's scale; and also to the number of degrees of an equal temperature on the Centigrade scale or otherwise.

The freezing points of water are 32° Fahrenheit, 0° Reaumur, 0° Centigrade; the boiling points of water are 212° F., 80° R., 100° C.; whence

FAHRENHEIT AND REAUMUR.

To convert degrees of Fahrenheit into degrees of Reaumur.

Multiply the difference between 32° and the given degrees of Fahrenheit, by 4, and divide by 9, the result will be degrees of Reaumur.

EXAMPLE 1.—Convert 77° of Fahrenheit into degrees of Reaumur.

Here $(77° \sim 32°) \times \frac{4}{9} = \frac{45° \times 4}{9} = 20°$ of Reaumur. = *Ans.*

EXAMPLE 2.—Turn 22° of Fahrenheit into degrees of Reaumur.

Here $(22° \sim 32°) \times \frac{4}{9} = \frac{10° \times 4}{9} = 4\frac{4}{9}°$ of Reaumur. = *Ans.*

FAHRENHEIT AND CENTIGRADE.

To convert degrees of Fahrenheit into Centigrade.

Multiply the difference between 32° and the given degrees of Fahrenheit, by 5, and divide by 9, the result is the number of degrees Centigrade.

EXAMPLE 3.—Convert 167° of Fahrenheit into Centigrade.

Here $(167° \sim 32°) \times \frac{5}{9} = \frac{135° \times 5}{9} = 75°$ Centigrade. = *Ans.*

EXAMPLE 4.—Convert 13° of Fahrenheit into Centigrade.

Here $(13° \sim 32°) \times \frac{5}{9} = \frac{19° \times 5}{9} = 10\frac{5}{9}°$ Centigrade. = *Ans.*

NOTE 1.—If the degrees of Fahrenheit are below 0°, take the sum instead of the difference between 32° and their quantity.

Thus (EXAMPLE 5) for 4° of Fahrenheit below 0° we have $(4° + 32°) \times \frac{4}{9} = \frac{36° \times 4}{9} = 16°$ of Reaumur. = *Ans.*, and

EXAMPLE 6.—$(4° + 32°) \times \frac{5}{9} = \frac{36° \times 5}{9} = 20°$ Centigrade. = *Ans.*

REAUMUR, CENTIGRADE, AND FAHRENHEIT.

1. Above the freezing point.—Multiply the degrees of Reaumur by 9, and divide by 4; or multiply the Centigrade degrees by 9, and divide by 5; the quotient, added to 32°, gives the degrees of Fahrenheit.

EXAMPLE 7.—Convert 20° of Reaumur into degrees of Fahrenheit.

Here $32° + \frac{20° \times 9}{4} = 32° + 45° = 77°$ of Fahrenheit. = *Ans.*

EXAMPLE 8.—Convert 75° Centigrade into degrees of Fahrenheit.

Here $32° + \frac{75° \times 9}{5} = 32° + 135° = 167°$ of Fahrenheit. = *Ans.*

2. Below the freezing point.—Multiply and divide the given degrees as before if they are Reaumur's degrees and less than $14\frac{2}{9}°$, or Centigrade and less than $17\frac{7}{9}°$, subtract the quotient from 32°, the result will be degrees of Fahrenheit above 0°.

But if the given degrees are not less than $14\frac{2}{9}°$, or $17\frac{7}{9}°$ respectively, subtract 32° from the quotient, the remainder will be degrees of Fahrenheit below 0°.

EXAMPLE 9.—Convert $4\frac{4}{9}°$ of Reaumur into Fahrenheit.

Here $32° - \frac{4\frac{4}{9}° \times 9}{4} = 32° - 10° = 22°$ of Fahrenheit. = *Ans.*

EXAMPLE 10.—Convert $10\frac{5}{9}°$ Centigrade into Fahrenheit degrees.

Here $32° - \frac{10\frac{5}{9}° \times 9}{5} = 32° - 19° = 13°$ of Fahrenheit. = *Ans.*

EXAMPLE 11.—Turn 16° of Reaumur into degrees Fahrenheit.

Here $\frac{16° \times 9}{4} - 32° = 36° - 32° = 4°$ below 0°. = *Ans.*

EXAMPLE 12.—Change 20° Centigrade into degrees Fahrenheit.

Here $\frac{20° \times 9}{5} - 32° = 36° - 32° = 4°$ of Fahrenheit below zero. = *Ans.*

NOTE 2.—5° on the Centigrade scale = 4° on Reaumur's scale.

TABLE

Showing the quantity and weight of a superficial foot of brick work, from half a brick to two and a half bricks in thickness.

Thickness by number.	Thickness in inches.	Number of bricks.	Weight in *lbs.* avoir.
$\frac{1}{2}$ brick	$4\frac{3}{4}$	4·58	40·19
1	$9\frac{1}{2}$	9·15	80·37
$1\frac{1}{2}$	$14\frac{1}{8}$	13·72	120·56
2	$18\frac{3}{4}$	18·3	160·74
$2\frac{1}{2}$	$23\frac{1}{2}$	22·875	200·93

NOTE.—The weight is independent of mortar.

1 brick weighs 9 *lbs.* avoirdupois, *nearly*; $12\frac{1}{2}$ = 1 *cwt.*, and 250 = 1 *ton.*

TABLE

Of the specific gravities of those bodies chiefly used in machinery, building, &c., showing, in avoirdupois ounces and pounds, the weight of a cubic foot of each body; also the weight of a cubic inch, and the number of cubic inches in a pound, with multipliers to each, for finding the weight when the dimensions are given.

Names of Bodies.	Weight of a Cubic Foot.		Weight of a Cubic Inch.		Number of Cubic Inches in a Pound.
	oz.	*lbs.*	*oz.*	*lbs.*	
Copper, cast	8788	549·25	5·086	·3178	3·146
Copper, sheet	8915	557·19	5·159	·3225	3·103
Brass, cast	8396	524·75	4·859	·3037	3·293
Iron, cast	7271	454·44	4·208	·263	3·802
Iron, bar	7788	486·75	4·507	·282	3·550
Lead	11344	709·00	6·565	·4103	2·437
Steel, soft	7833	489·56	4·533	·2833	3·530
Steel, hard	7816	488·50	4·523	·2827	3·537
Zinc, cast	7190	449 37	4·161	·26	3·845
Tin, cast	7292	455·75	4·222	·2636	3·792
Bismuth	9880	617·50	5·718	·3574	2·798
Gun Metal	8784	549·00	5·083	·3177	3·148
Sand	1520	95·00	·880	·055	18·190
Coal	1250	78·12	·723	·0452	22·118
Brick	2000	125·00	1·157	·0723	13·824
Stone, paving	2416	151·00	1·398	·0873	11·444
Slate	2672	167·00	1·546	·0967	10·347
Marble	2742	171·37	1·587	·0991	10·083
White lead	3160	197·50	1·829	·1143	8·749
Glass	2880	180·00	1·667	·1042	9·600
Tallow	945	59·06	·547	·0342	29·257
Cork	240	15·00	·139	·0087	115·200
Larch	544	34·00	·315	·0197	50·823
Elm	671	41·94	·388	·0204	41·204
Pine, pitch	660	41·25	·382	·024	41·890
Beech	852	53·25	·493	·0308	32·451
Teak	745	46 56	·431	·027	37·111
Ash	845	52·81	·489	·0305	32·720
Mahogany	1063	66·44	·615	·0384	26·009
Oak	970	60·62	·561	·0351	28·503
Oil of Turpentine	870	54·37	·503	·0315	31·779
Olive Oil	915	57·19	·529	·0331	30·216
Linseed Oil	932	58·25	·539	·0337	29·665
Spirits, proof	927	57·94	·536	·03352	29·825
Water, distilled	1000	62·50	·579	·03617	27·648
Water, sea	1028	64·25	·595	·0372	26·895
Tar	1015	63·44	·587	·0367	27·239
Vinegar	1026	64·12	·594	·037	26 947
Mercury	13568	848·00	7·852	·4907	2·038

The 1*st*, 2*nd*, 3*rd*, and 4*th* columns require no further explanation than the titles they bear; the fifth column is to find the weight of any number of cubic inches, in avoirdupois pounds, of any of the different bodies required.

Example 1.—Suppose a piece of cast iron to be $56\frac{3}{4}$ inches long, $16\frac{1}{2}$ inches broad, and $\frac{3}{4}$ of an inch in thickness, required its weight.

Here $56{\cdot}75 \times 16{\cdot}5 \times {\cdot}75 = 702{\cdot}28125$ cubic inches, which multiplied by $\cdot 263 = 184{\cdot}7$ *lbs.*, *nearly*. = *Ans.*

Example 2.—Required the weight of an imperial gallon of proof spirits.

Here $277{\cdot}274 \times {\cdot}03352 = 9{\cdot}294$ *lbs*, *nearly*. = *Ans.*

Example 3.—Required the thickness of metal for a concave copper ball, 8 inches diameter without, so as to sink to its centre in common water.

Here $8^3 \times {\cdot}5236 = 268{\cdot}0832$ cubic inches in the ball, the half of which = 134·0416 cubic inches to be immersed, or cubic inches of water to be removed.—Then $134{\cdot}0416 \times {\cdot}579$ (the weight of a cubic inch of water) = 77·6100864 ounces weight of water displaced, or the weight of the copper ball; which divided by 5·159 (the weight of a cubic inch of copper) = 15·0436 cubic inches of copper in the ball.

Again, $8^2 \times {\cdot}7854 \times 4 = 201{\cdot}0624$ square inches, the superficies of the ball; and $15{\cdot}0436 \div 201{\cdot}0624 = {\cdot}0748$ inches, the required thickness of the copper, *nearly*. = *Ans.*

Example 4.—Required the weight necessary to counterpoise a float of paving stone proper for a steam-engine boiler, &c., the float being 14 inches diameter and $2\frac{1}{2}$ inches thick.

Here $14^2 \times {\cdot}7854 \times 2{\cdot}5 = 384{\cdot}846$ cubic inches. Then $384{\cdot}846 \times {\cdot}0873$ = the weight of the stone in *lbs.* And, $384{\cdot}846 \times {\cdot}03617$ = the weight in *lbs.* of water displaced; then, $384{\cdot}846 \times ({\cdot}0873 - {\cdot}03617) = 384{\cdot}846 \times {\cdot}05113 = 19{\cdot}677$ *lbs.* the counterpoise required. = *Ans.*

RULES

FOR MAKING OR CORRECTING THE GAUGE POINTS ON THE ENGINEER'S SLIDE RULE.

The engineer's slide rule is an instrument of extensive use to mechanics, and almost every one who is in possession of the rule, is also, or may be, in ample possession of instructions; but I am not aware that any information has been given in any other work, for either correcting the old gauge points, or obtaining new ones; hence the following may be found useful:—

And first, by making the third column on the rule (or that marked III) the first of our observations, the others are rendered very simple; thus,

The third column is the number of cubic inches contained in a pound, foot, gallon, &c.

The second column is the numbers in the third column expressed in the decimals of a foot, or multiplied by ·833.

The first column is the third column divided by 1728.

The fifth column is the third column divided by ·7854.

The fourth column is the fifth column expressed in the decimals of a foot, or multiplied by ·833.

The seventh column is the third column divided by ·5236. And,

The sixth column is the seventh column divided by 1728.

DECIMAL APPROXIMATIONS FOR FACILITATING CALCULATIONS IN MENSURATION.

Lineal feet	multiplied by	·000189	= miles.
,, yards	,,	·000568	= ,,
Square inches	,,	·00694′	= square feet.
,, yards	,,	·0002066	= acres.
Circular inches	,,	·005454	= square feet.
Cylindrical inches	,,	·0004645	= cubic feet.
,, feet	,,	·02908′	= cubic yards.
Cubic inches	,,	·0005787	= cubic feet.
,, feet	,,	·037′	= cubic yards.
,, ,,	,,	6·232	= imperial gallons.
,, inches	,,	·0036065	= ,, ,,
Cylindrical feet	,,	4·895	= ,, ,,
,, inches	,,	·002832	= ,, ,,
Cubic inches	,,	·2630	= *lbs.* avs. of cast iron.
,,	,,	·2817	= ,, wrought do.
,,	,,	·2833	= ,, steel.
,,	,,	·3225	= ,, copper.
,,	,,	·3037	= ,, brass.
,,	,,	·2601	= ,, zinc.
,,	,,	·4103	= ,, lead.
,,	,,	·2636	= ,, tin.
,,	,,	·4908	= ,, mercury.
Cylindrical inches	,,	·2065	= ,, cast iron.
,,	,,	·2212	= ,, wrought iron.
,,	,,	·2225	= ,, steel.
,,	,,	·2533	= ,, copper.
,,	,,	·2385	= ,, brass.
,,	,,	·2043	= ,, zinc.
,,	,,	·3223	= ,, lead.
,,	,,	·2071	= ,, tin.
,,	,,	·3854	= ,, mercury.
Avoirdupois *lbs.*	,,	·0089	= *cwts.*
,,	,,	·000446	= *tons.*

DECIMAL EQUIVALENTS TO FRACTIONAL PARTS OF LINEAL MEASURES.

One inch, the integer or whole number.

·96875	are equal to	$\frac{7}{8}+\frac{3}{32}$	·625	are equal to	$\frac{5}{8}$	·28125	are equal to	$\frac{1}{4}+\frac{1}{32}$
·9375		$\frac{7}{8}+\frac{1}{16}$	·59375		$\frac{1}{2}+\frac{3}{32}$	·25		$\frac{1}{4}$
·90625		$\frac{7}{8}+\frac{1}{32}$	·5625		$\frac{1}{2}+\frac{1}{16}$	·21875		$\frac{1}{8}+\frac{3}{32}$
·875		$\frac{7}{8}$	·53125		$\frac{1}{2}+\frac{1}{32}$	·1875		$\frac{1}{8}+\frac{1}{16}$
·84375		$\frac{3}{4}+\frac{3}{32}$	·5		$\frac{1}{2}$	·15625		$\frac{1}{8}+\frac{1}{32}$
·8125		$\frac{3}{4}+\frac{1}{16}$	·46875		$\frac{3}{8}+\frac{3}{32}$	·125		$\frac{1}{8}$
·78125		$\frac{3}{4}+\frac{1}{32}$	·4375		$\frac{3}{8}+\frac{1}{16}$	·09375		$\frac{3}{32}$
·75		$\frac{3}{4}$	·40625		$\frac{3}{8}+\frac{1}{32}$	·0625		$\frac{1}{16}$
·71875		$\frac{5}{8}+\frac{3}{32}$	·375		$\frac{3}{8}$	·03125		$\frac{1}{32}$
·6875		$\frac{5}{8}+\frac{1}{16}$	·34375		$\frac{1}{4}+\frac{1}{32}$			
·65625		$\frac{5}{8}+\frac{1}{32}$	·3125		$\frac{1}{4}+\frac{1}{16}$			

One foot, or 12 inches, the integer.

·9166′	are equal to	11 inches.	·4166′	are equal to	5 inches.	·0625	are equal to	$\frac{3}{4}$ of in.
·8333′		10 ,,	·3333′		4 ,,	·05208		$\frac{5}{8}$,,
·75		9 ,,	·25		3 ,,	·04167		$\frac{1}{2}$,,
·6666′		8 ,,	·1666′		2 ,,	·03125		$\frac{3}{8}$,,
·5833′		7 ,,	·0833′		1 ,,	·02083		$\frac{1}{4}$,,
·5		6 ,,	·07292		$\frac{7}{8}$,,	·01042		$\frac{1}{8}$,,

One yard, or 36 inches, the integer.

·972′	are equal to	35 inches.	·638′	are equal to	23 inches.	·305′	are equal to	11 inches.
·944′		34 ,,	·611′		22 ,,	·277′		10 ,,
·916′		33 ,,	·583′		21 ,,	·25		9 ,,
·888′		32 ,,	·555′		20 ,,	·222′		8 ,,
·861′		31 ,,	·527′		19 ,,	·194′		7 ,,
·833′		30 ,,	·5		18 ,,	·166′		6 ,,
·805′		29 ,,	·472′		17 ,,	·138′		5 ,,
·777′		28 ,,	·444′		16 ,,	·111′		4 ,,
·75		27 ,,	·416′		15 ,,	·083′		3 ,,
·722′		26 ,,	·388′		14 ,,	·055′		2 ,,
·694′		25 ,,	·361′		13 ,,	·027′		1 ,,
·666′		24 ,,	·333′		12 ,,			

TABLE

Containing the price of metals, or other materials, by the ton, cwt., quarter, or lb.

Per ton.	Per cwt.	Per qrtr.	℔ lb.	Per ton.	Per cwt.	Per qrtr.	℔ lb.	Per ton.	Per cwt.	Per qrtr.	℔ lb
£ s. d.	s. d.	s. d.	d.	£ s. d.	£ s. d.	s. d.	d.	£ s. d.	£ s. d.	£ s. d.	d.
2 6 8	2 4	0 7	¼	14 10 0	0 14 6	3 7½	...	32 10 0	1 12 6	0 8 1½	
2 10 0	2 6	0 7½	...	14 15 0	0 14 9	3 8¼	...	32 13 4	1 12 8	0 8 2	...
2 15 0	2 9	0 8¼	...	15 0 0	0 15 0	3 9	...	33 0 0	1 13 0	0 8 3	
3 0 0	3 0	0 9	...	15 5 0	0 15 3	3 9¾	...	33 10 0	1 13 6	0 8 4½	...
3 5 0	3 3	0 9¾	...	15 10 0	0 15 6	3 10½	...	34 0 0	1 14 0	0 8 6	...
3 10 0	3 6	0 10½	...	15 15 0	0 15 9	3 11¼	...	34 10 0	1 14 6	0 8 7½	...
3 15 0	3 9	0 11¼	...	16 0 0	0 16 0	4 0	...	35 0 0	1 15 0	0 8 9	3¾
4 0 0	4 0	1 0	...	16 5 0	0 16 3	4 0¾	...	35 10 0	1 15 6	0 8 10½	...
4 5 0	4 3	1 0¾	...	16 6 8	0 16 4	4 1	1¾	36 0 0	1 16 0	0 9 0	...
4 10 0	4 6	1 1½	...	16 10 0	0 16 6	4 1½	...	36 10 0	1 16 6	0 9 1½	...
4 13 4	4 8	1 2	½	16 15 0	0 16 9	4 2¼	...	37 0 0	1 17 0	0 9 3	...
4 15 0	4 9	1 2¼	...	17 0 0	0 17 0	4 3	...	37 6 8	1 17 4	0 9 4	4
5 0 0	5 0	1 3	...	17 5 0	0 17 3	4 3¾	...	37 10 0	1 17 6	0 9 4½	...
5 5 0	5 3	1 3¾	...	17 10 0	0 17 6	4 4½	...	38 0 0	1 18 0	0 9 6	...
5 10 0	5 6	1 4½	...	17 15 0	0 17 9	4 5¼	...	38 10 0	1 18 6	0 9 7½	...
5 15 0	5 9	1 5¼	...	18 0 0	0 18 0	4 6	...	39 0 0	1 19 0	0 9 9	...
6 0 0	6 0	1 6	...	18 5 0	0 18 3	4 6¾	...	39 10 0	1 19 6	0 9 10½	...
6 5 0	6 3	1 6¾	...	18 10 0	0 18 6	4 7½	...	39 13 4	19 8	0 9 11	4¼
6 10 0	6 6	1 7½	...	18 13 4	0 18 8	4 8	2	40 0 0	2 0 0	0 10 0	...
6 15 0	6 9	1 8¼	...	18 15 0	0 18 9	4 8¼	...	40 10 0	2 0 6	0 10 1½	...
7 0 0	7 0	1 9	¾	19 0 0	0 19 0	4 9	...	41 0 0	2 1 0	0 10 3	...
7 5 0	7 3	1 9¾	...	19 5 0	0 19 3	4 9¾	...	41 10 0	2 1 6	0 10 4½	...
7 10 0	7 6	1 10½	...	19 10 0	0 19 6	4 10½	...	42 0 0	2 2 0	0 10 6	4½
7 15 0	7 9	1 11¼	...	19 15 0	0 19 9	4 11¼	...	44 6 8	2 4 4	0 11 1	4¾
8 0 0	8 0	2 0	...	20 0 0	1 0 0	5 0	...	46 13 4	2 6 8	0 11 8	5
8 5 0	8 3	2 0¾	...	20 10 0	1 0 6	5 1½	...	49 0 0	2 9 0	0 12 3	5¼
8 10 0	8 6	2 1½	...	21 0 0	1 1 0	5 3	2¼	51 6 8	2 11 4	0 12 10	5½
8 15 0	8 9	2 2¼	...	21 10 0	1 1 6	5 4½	...	53 13 4	2 13 8	0 13 5	5¾
9 0 0	9 0	2 3	...	22 0 0	1 2 0	5 6	...	56 0 0	2 16 0	0 14 0	6
9 5 0	9 3	2 3¾	...	22 10 0	1 2 6	5 7½	...	58 6 8	2 18 4	0 14 7	6¼
9 6 8	9 4	2 4	1	23 0 0	1 3 0	5 9	...	60 13 4	3 0 8	0 15 2	6½
9 10 0	9 6	2 4½	...	23 6 8	1 3 4	5 10	2½	63 0 0	3 3 0	0 15 9	6¾
9 15 0	9 9	2 5¼	...	23 10 0	1 3 6	5 10½	...	65 6 8	3 5 4	0 16 4	7
10 0 0	10 0	2 6	...	24 0 0	1 4 0	6 0	...	67 13 4	3 7 8	0 16 11	7¼
10 5 0	10 3	2 6¾	...	24 10 0	1 4 6	6 1½	...	70 0 0	3 10 0	0 17 6	7½
10 10 0	10 6	2 7½	...	25 0 0	1 5 0	6 3	...	72 6 8	3 12 4	0 18 1	7¾
10 15 0	10 9	2 8¼	...	25 10 0	1 5 6	6 4½	...	74 13 4	3 14 8	0 18 8	8
11 0 0	11 0	2 9	...	25 13 4	1 5 8	6 5	2¾	77 0 0	3 17 0	0 19 3	8¼
11 5 0	11 3	2 9¾	..	26 0 0	1 6 0	6 6	...	79 6 8	3 19 4	0 19 10	8½
11 10 0	11 6	2 10½	...	26 10 0	1 6 6	6 7½	...	81 13 4	4 1 8	1 0 5	8¾
11 13 4	11 8	2 11	1¼	27 0 0	1 7 0	6 9	...	84 0 0	4 4 0	1 1 0	9
11 15 0	11 9	2 11¼	...	27 10 0	1 7 6	6 10½	...	86 6 8	4 6 4	1 1 7	9¼
12 0 0	12 0	3 0	...	28 0 0	1 8 0	7 0	3	88 13 4	4 8 8	1 2 2	9½
12 5 0	12 3	3 0¾	...	28 10 0	1 8 6	7 1½	...	91 0 0	4 11 0	1 2 9	9¾
12 10 0	12 6	3 1½	...	29 0 0	1 9 0	7 3	...	93 6 8	4 13 4	1 3 4	10
12 15 0	12 9	3 2¼	...	29 10 0	1 9 6	7 4½	...	95 13 4	4 15 8	1 3 11	10¼
13 0 0	13 0	3 3	...	30 0 0	1 10 0	7 6	...	98 0 0	4 18 0	1 4 6	10½
13 5 0	13 3	3 3¾	...	30 6 8	1 10 4	7 7	3¼	100 6 8	5 0 4	1 5 1	10¾
13 10 0	13 6	3 4½	...	30 10 0	1 10 6	7 7½	...	102 13 4	5 2 8	1 5 8	11
13 15 0	13 9	3 5¼	...	31 0 0	1 11 0	7 9	...	107 6 8	5 7 4	1 6 10	11½
14 0 0	14 0	3 6	1½	31 10 0	1 11 6	7 10½	...	112 0 0	5 12 0	1 8 0	12
14 5 0	14 3	3 6¾	...	32 0 0	1 12 0	8 0	...	126 0 0	6 6 0	1 11 6	13½

A TABLE, BY SAMUEL MAYNARD,

Containing useful numbers often required in calculations, together with their Logarithms.

NOTE.—Some portion of the following Table has already appeared, by the present editor, in other publications; among which may be mentioned Keith's Measurer (twenty-fourth edition, 1846). The numbers in that portion, however, have all been recomputed, and an amplification has been given to them which the Author believes to surpass any similar collection. He feels confidence in their strict accuracy, and hopes they will be found to be carried to an extent sufficient for every purpose of calculation.

By the combination of the six following logarithms, viz. of 2, 3, 15, 77, 94, and 487 (extracted from the table of logarithms to 61 decimal places in Abraham Sharp's Geometry Improved, p. 56, edit. of 1717), with log π, all the logarithms in the following table have been constructed; with the exception of the logarithm of the imperial gallon No. (86), which has been computed by Hutton's 20-figure logarithm table.

Log.	2 = 0·30102	99956	63981	19521	37388	94724	49303	Log.	77 = 1·88649	07251	72481	87146	24162	29835	66044
,,	3 = 0·47712	12547	19662	43729	50279	03255	11531	,,	94 = 1·97312	78535	99698	65962	79582	94173	69367
,,	15 = 1·17609	12590	55681	24208	12890	08530	62228	,,	487 = 2·68752	89612	14634	33246	32050	64435	75372

NUMBERS.	LOGARITHMS.
By means of Euler's formula, $\frac{\pi}{4} = 4\tan^{-1}\frac{1}{5} - \tan^{-1}\frac{1}{70} + \tan^{-1}\frac{1}{99}$ wherein π represents the circumference of a circle whose diameter is unity, Mr. William Rutherford, F.R.A.S., of the Royal Military Academy, Woolwich, has obtained the following value of π to 208 decimal places (see *Philosophical Transactions of London*, Part ii. for 1841, p. 281): viz.	
(1) π = 3·14159 26535 89793 23846 26433 83279 50288 41971 69399 37510 58209 74944 59230 78164 06286 20899 86280 34825 34211 70679 82148 08651 32823 06647 09384 46095 50582 23172 53594 08128 48473 78139 20386 33830 21574 73996 00825 93125 91294 01832 80651 744 + &c. the circumference of a circle whose diameter is 1 = area of a circle whose radius is 1; which, to 135 decimals, agrees with VEGA.	0·49714 98726 94133 85435 12682 88291 *Abraham Sharp, in Sherwin's Table of Logarithms* (edit. of 1726, p. 42).

NUMBERS.	LOGARITHMS.
(2) 2π = 6·28318 53071 79586 47692 52867 66559, the circumference of a circle whose radius is 1.	0·79817 98683 58115 04956 50071 83015
(3) 4π = 12·56637 06143 59172 95385 05735 33118 = $2\pi \times 2$, the surface of a sphere whose radius is 1.	1·09920 98640 22096 24477 87460 77740
(4) 36π = 113·09733 55292 32556 58465 51617 98062 = $4\pi \times 9$ = the surface and solidity of a sphere whose diameter is 6.	2·05345 23734 61421 11936 88018 84250
(5) $\frac{1}{2}\pi$ = 1·57079 63267 94896 61923 13216 91640 = semicircumference of a circle whose diameter is 1 = quadrantal arc of a circle whose radius is 1.	0·19611 98770 30152 65913 75293 93566
(6) $\frac{1}{3}\pi$ = 1·04719 75511 96597 74615 42144 61093 = arc of a circle whose chord equals the radius.	0·02002 86179 74471 41705 62403 85036
(7) $\frac{1}{4}\pi$ = 0·78539 81633 97448 30961 56608 45820 = $\frac{1}{2}$ of $\frac{1}{2}\pi$ = quadrantal arc of a circle whose diameter is 1 = area of a circle whose diameter is 1.	9·89508 98813 66171 46392 37904 98842—10
(8) $\frac{1}{6}\pi$ = 0·52359 87755 98298 87307 71072 30547 = $\frac{1}{4}\pi - \frac{1}{3}$ of $\frac{1}{4}\pi$ = arc of 60° to diameter 1 = solidity of a sphere whose diameter is 1.	9·71899 86223 10490 22184 25014 90311—10
(9) $\frac{1}{8}\pi$ = 0·39269 90816 98724 15480 78304 22910 = $\frac{1}{6}\pi - \frac{1}{4}$ of $\frac{1}{6}\pi$ = arc of 45° to diameter 1.	9·59405 98857 02190 26871 00516 04117—10
(10) $\frac{1}{12}\pi$ = 0 26179 93877 99149 43653 85536 15273 = $\frac{1}{8}\pi - \frac{1}{3}$ of $\frac{1}{8}\pi$ = arc of 30° to diameter 1.	9·41796 86266 46509 02662 87625 95587—10
(11) $\frac{1}{24}\pi$ = 0·13089 96938 99574 71826 92768 07637 = $\frac{1}{2}$ of $\frac{1}{12}\pi$ = arc of 15° to diameter 1.	9·11693 86309 82527 83141 50237 00862—10
(12) $\frac{1}{180}\pi$ = 0·01745 32925 19943 29576 92369 07685 = $\frac{4}{30}$ of $\frac{1}{24}\pi$ = arc of 1° to radius 1.	8·24187 73675 90827 78454 74735 87056—10
(13) $\frac{1}{360}\pi$ = 0·00872 66462 59971 64788 46184 53842 = $\frac{1}{2}$ of $\frac{1}{180}\pi$ = arc of 30′ to radius 1.	7 91084 73719 26846 58933 37346 92332—10

(14) $\frac{1}{10800}\pi$	= 0·00029 08882 08665 72159 61539 48461 = $\frac{1}{30}$ of $\frac{1}{360}\pi$ = arc of 1′ to radius 1.	6·46372 61172 07184 15203 87067 89077—10
(15) $\frac{1}{648000}\pi$	= 0·00000 48481 36811 09535 99358 99141 = $\frac{1}{60}$ of $\frac{1}{10800}\pi$ = arc of 1″ to radius 1.	4·68557 48668 23540 51952 99399 91097—10
(16) $\frac{2}{3}\pi$	= 2·09439 51023 93195 49230 84289 22186 = $\frac{1}{3}$ of 2π = arc of 120° to radius 1.	0·32105 86136 38452 61226 99792 79760
(17) $\frac{4}{3}\pi$	= 4·18879 02047 86390 98461 68578 44373 = $\frac{1}{3}$ of 4π = arc of 240° to radius 1 = solidity of a sphere whose radius is 1.	0·62208 86093 02433 80748 37181 74485
(18) $\sqrt{2}$	= 1·41421 35623 73095 04880 16887 24209 7, the diagonal of a square whose side is 1.	0·15051 49978 31990 59760 68694 47362
(19) $\sqrt{\frac{1}{2}}$	= 0·70710 67811 86547 52440 08443 62104 8 = $\frac{1}{2}\sqrt{2}$, the side of a square whose diagonal is 1.	9·84948 50021 68009 40239 31305 52638—10
(20) $\pi\sqrt{2}$	= 4·44288 29381 58366 24701 58809 90060 7, the circumference of the circle circumscribing a square whose side is 1.	0·64766 48705 26124 45195 81377 35653
(21) $\pi\sqrt{\frac{1}{2}}$	= 2·22144 14690 79183 12350 79404 95030 3, the $\frac{1}{2}$ of $\pi\sqrt{2}$, the circumference of a circle circumscribing a square whose side = $\frac{1}{2}$.	0·34663 48748 62143 25674 43988 40929
(22) π^2	= 9·86960 44010 89358 61883 44909 99876	0·99429 97453 88267 70870 25365 76582
(23) $6\pi^2$	= 59·21762 64065 36151 71300 69459 99257	1·77245 09957 71911 34121 13033 74561
(24) $\frac{1}{\pi}$	= 0·31830 98861 83790 67153 77675 26745, the reciprocal of π, the diameter of a circle whose circumference is 1.	9 50285 01273 05866 14564 87317 11709—10
(25) $\frac{2}{\pi}$	= 0·63661 97723 67581 34307 55350 53490 = $\frac{1}{\pi} \times 2$.	9·80388 01229 69847 34086 24706 06434—10
(26) $\frac{4}{\pi}$	= 1·27323 95447 35162 68615 10701 06980 = $\frac{2}{\pi} \times 2$.	0·10491 01186 33828 53607 62095 01158

NUMBERS.	LOGARITHMS.
(27) $\frac{6}{\pi}$ = 1·90985 93171 02744 02922 66051 60470 = $\frac{4}{\pi}$ + $\frac{1}{2}$ of $\frac{4}{\pi}$	0·28100 13776 89509 77815 74985 09689
(28) $\frac{180}{\pi}$ = 57·29577 95130 82320 87679 81548 14111 = $\frac{6}{\pi}$ × 30, the number of degrees and decimal parts in an arc equal to the radius; which, expressed in degrees, minutes, and seconds, and decimals of a second, is 57° 17′ 44″ ·806247096.	1·75812 26324 09172 21545 25264 12944
(29) $\frac{360}{\pi}$ = 114·59155 90261 64641 75359 63096 28221 = $\frac{180}{\pi}$ × 2, the number of degrees and decimal parts in an arc equal to the diameter.	2·05915 26280 73153 41066 62653 07668
(30) $\frac{10800}{\pi}$ = 3437·74677 07849 39252 60788 92888 46637 = $\frac{360}{\pi}$ × 30, the number of minutes and decimal parts in an arc equal to the radius; which, expressed in minutes, seconds, and decimals of a second, is 3437′ 44″ ·806247096.	3·53627 38827 92815 84796 12932 10923
(31) $\frac{648000}{\pi}$ = 206264·80624 70963 55156 47335 73307 98214 = $\frac{10800}{\pi}$ × 60, the number of seconds and decimal parts in an arc equal to the radius.	5·31442 51331 76459 48047 00600 08903
(32) 60 = the base of the sexagesimal scale.	1·77815 12503 83643 63250 87667 97980
(33) 360 = the number of degrees in the circle, sexagesimal or ancient division.	2·55630 25007 67287 26501 75335 95959
(34) 21600 = the number of minutes in the circle, according to the ancient or sexagesimal division = 360 × 60.	4·33445 37511 50930 89752 63003 93939
(35) 1296000 = the number of seconds in the circle, according to the ancient or sexagesimal division = 21600 × 60.	6·11260 50015 34574 53003 50671 91918
(36) 100 = base of the French or centesimal scale.	2·00000 00000 00000 00000 00000 00000

(37)	400 = the number of degrees in the circle, according to the French or centesimal division.	2·60205 99913 27962 39042 74777 89449
(38)	40000 = 400 × 100 = the number of minutes in the circle, according to the French or centesimal division.	4·60205 99913 27962 39042 74777 89449
(39)	4000000 = 40000 × 100 = the number of seconds in the circle, according to the French or centesimal division.	6·60205 99913 27962 39042 74777 89449
(40)	$\frac{400}{\pi}$ = 127·32395 44735 16268 61510 70106 98024 = $\frac{4}{\pi} \times 100$, the number of French or centesimal degrees and decimal parts in an arc equal to the radius.	2·10491 01186 33828 53607 62095 01158
(41)	$\frac{40000}{\pi}$ = 12732·39544 73516 26861 51070 10698 02359 = $\frac{400}{\pi}$ × 100, the number of French or centesimal minutes in an arc equal to the radius.	4·10491 01186 33828 53607 62095 01158
(42)	$\frac{4000000}{\pi}$ = 1273239·54473 51626 86151 07010 69802 35888 = $\frac{40000}{\pi}$ × 100, the number of French or centesimal seconds in an arc equal to the radius.	6·10491 01186 33828 53607 62095 01158
(43)	$\frac{\pi}{200}$ = 0·01570 79632 67948 96619 23132 16916 = arc of 1 centesimal degree to radius 1.	8·19611 98770 30152 65913 75293 93566—10
(44)	$\frac{\pi}{20000}$ = 0·00015 70796 32679 48966 19231 32169 = $\frac{1}{100}$ of $\frac{\pi}{200}$ = arc of 1 centesimal minute to radius 1.	6·19611 98770 30152 65913 75293 93566—10
(45)	$\frac{\pi}{2000000}$ = 0·00000 15707 96326 79489 66192 31322 = $\frac{1}{100}$ of $\frac{\pi}{20000}$ = arc of 1 centesimal second to radius 1.	4·19611 98770 30152 65913 75293 93566—10
(46)	$\frac{1}{2\pi}$ = 0·15915 49430 91895 33576 88837 63373 = $\frac{1}{2}$ of $\frac{1}{\pi}$	9·20182 01316 41884 95043 49928 16985—10

NUMBERS.	LOGARITHMS.
(47) $\frac{1}{4\pi}$ =0·07957 74715 45947 66788 44418 81686 = ½ of $\frac{1}{2\pi}$ the area of a circle whose circumference is 1.	8·90079 01359 77903 75522 12539 22260—10
(48) $\frac{1}{6\pi}$ =0·05305 16476 97298 44525 62945 87791 = $\frac{1}{4\pi} - \frac{1}{3}$ of $\frac{1}{4\pi}$	8·72469 88769 22222 51313 99649 13729—10
(49) $\frac{1}{\pi}\sqrt{2}$ =0·45015 81580 78553 03477 75995 95503	9·65336 51251 37856 74325 56011 59071—10
(50) $\frac{1}{\pi}\sqrt{\frac{1}{2}}$ =0·22507 90790 39276 51738 87997 97752 = ½ of $\frac{1}{\pi}\sqrt{2}$	9·35233 51294 73875 54804 18622 64347—10
(51) $\frac{1}{\pi^2}$ =0·10132 11836 42337 77144 38794 63210	9·00570 02546 11732 29129 74634 23418—10
(52) $\frac{1}{2\pi^2}$ =0·05066 05918 21168 88572 19397 31605 = ½ of $\frac{1}{\pi^2}$	8 70467 02589 47751 09608 37245 28691—10
(53) $\frac{1}{6\pi^2}$ =0·01688 68639 40389 62857 39799 10535 = ⅓ of $\frac{1}{2\pi^2}$	8·22754 90042 28088 65878 86966 25439—10
(54) $\sqrt{\pi}$ =1·77245 38509 05516 02729 81674 83341, the side of a square equal in surface to a circle whose radius is 1.	0·24857 49363 47066 92717 56341 44145
(55) $2\sqrt{\pi}$ =3·54490 77018 11032 05459 63349 66682, the circumference of a circle whose area is 1.	0·54960 49320 11048 12238 93730 38870
(56) $\frac{1}{2}\sqrt{\pi}$ =0·88622 69254 52758 01364 90837 41671, ½ of $2\sqrt{\pi}$ the side of a square equal in surface to a circle whose diameter is 1.	9·94754 49406 83085 73196 18952 49421—10
(57) $\frac{1}{8}\sqrt{\pi}$ =0·22155 67313 63189 50341 22709 35418 = ¼ of ½ $\sqrt{\pi}$.	9·34548 49493 55123 34153 44174 59972—10
(58) $\sqrt{\frac{\pi}{2}}$ =1·25331 41373 15500 25120 78826 42406	0·09805 99385 15076 32956 87646 06783

(59)	$\sqrt{\frac{1}{\pi}}$ = 0·56418 95835 47756 28694 80794 51560, the reciprocal of $\sqrt{\pi}$, the diameter of a sphere whose surface is 1.	9·75142 50636 52933 07282 43658 55855—10
(60)	$2\sqrt{\frac{1}{\pi}}$ = 1·12837 91670 95512 57389 61589 03120, the diameter of a circle equal in surface to a square whose side is 1.	0·05245 50593 16914 26803 81047 50579
(61)	$\frac{1}{2}\sqrt{\frac{1}{\pi}}$ = 0·28209 47917 73878 14347 40397 25780 = $\frac{1}{4}$ of $2\sqrt{\frac{1}{\pi}}$	9·45039 50679 88951 87761 06269 61130—10
(62)	$\frac{1}{6}\sqrt{\frac{1}{\pi}}$ = 0·09403 15972 57959 38115 80132 41927 = $\frac{1}{3}$ of $\frac{1}{2}\sqrt{\frac{1}{\pi}}$	8·97327 38132 69289 44031 55990 57875—10
(63)	$\frac{1}{8}\sqrt{\frac{1}{\pi}}$ = 0·07052 36979 43469 53586 85099 31445 = $\frac{1}{6}\sqrt{\frac{1}{\pi}}$ — $\frac{1}{4}$ of $\frac{1}{6}\sqrt{\frac{1}{\pi}}$	8·84833 50766 60989 48718 31491 71681—10
(64)	$\sqrt{\frac{2}{\pi}}$ = 0·79788 45608 02865 35587 98921 19876 = $\sqrt{2} \times \sqrt{\frac{1}{\pi}}$	9·90194 00614 84923 67043 12353 03217—10
(65)	$\sqrt[3]{36\pi}$ = 4·83597 58620 5, the side of a cube equal in solid content to a sphere whose diameter is 6.	0·68448 41244 87140 37312 29339 61417—10
(66)	$\sqrt[3]{\frac{\pi}{6}}$ = 0 80599 59770 1 = $\frac{1}{6}$ of $\sqrt[3]{36\pi}$. the side of a cube equal in solid content to a sphere whose diameter is 1.	9·90633 28741 03496 74061 41671 63437—10
(67)	$\sqrt[3]{6\pi^2}$ = 3·89777 707	0·59081 69985 90637 11373 71011 24854
(68)	$\sqrt[3]{\frac{6}{\pi}}$ = 1·24070 09818	0·09366 71258 96503 25938 58328 36563
(69)	24 = the number of hours in a day.	1·38021 12417 11606 02293 62445 87429
(70)	1440 = the number of minutes in a day = 24 × 60.	3·15836 24920 95249 65544 50113 85408
(71)	86400 = the number of seconds in a day = 1440 × 60.	4·93651 37424 78893 28795 37781 83388
(72)	60 = the number of minutes in 1 hour.	1·77815 12503 83613 63250 87667 97980
(73)	3600 = the number of seconds in 1 hour = 60 × 60 = 60^2.	3·55630 25007 67287 26501 75335 95959

	NUMBERS.		LOGARITHMS.
(74)	47336400000	= the number of days in which a body moving uniformly at the rate of 1″ sexagesimal in a Julian century or 36525 days describes one revolution or 1296000″ sexagesimal seconds, this number being equal to $36525 \times 1296000 = 36525000 \times 6 \times 6 \times 6 \times 6$.	10·67519 52261 40908 90936 58223 70160
(75)	146100000000	= the number of days in which a body moving uniformly at the rate of 1″ centesimal in a Julian century or 36525 days describes one revolution or 4000000 centesimal seconds, this number being equal to 36525×4000000.	11·16465 02159 34296 76975 82329 67691
(76)	3999930·09	= the number of centesimal seconds (according to Laplace, Mécanique Céleste, tome troisième, page 64) which the earth describes in a Julian century or 36525 days.	
(77)	365·25638 37684	= the number of days and decimal parts in a sidereal year, equal to $146100000000 \div 399993039$.	
(78)	129597738·2344	= the number of sexagesimal seconds, according to Bessel, which the earth describes in a Julian century or 36525 days.—*Connaissance des Tems, Additions. Année* 1831, p. 154.	
(79)	365·25637 44159	= the number of days and decimal parts in a sidereal year, equal to $47336400000 \div 129597738{\cdot}2344$; or,	
(80)	129597734·2891	= the number of sexagesimal seconds which the earth, according to another determination, describes in a Julian century or 36525 days.	
(81)	365·25638 55353	= the number of days and decimal parts in a sidereal year, according to the preceding motion = 365*d*. 6*h*. 9*m*. 11·71025*s*. 365*d*. 6*h*. 9*m*. 10·74953*s*., according to Bessel. 365*d*. 6*h*. 9*m* 11·55759*s*., according to Delambre and Laplace.	

(82)	39·14997 = length of Bessel's seconds pendulum in a vacuum, at the level of the sea, in latitude 54° 42′ 50″ (Königsberg).	
(83)	39·13907 = length of seconds pendulum, deduced from the preceding to London (lat. 51° 31′ 8″).	
(84)	252·458 grains troy = weight of a cubic inch of distilled water at the temperature of 62° Fahrenheit. (English Measures, *Act* 5 G. 4, *c.* 74.)	2·40218 91373 63903 3
(85)	7000 grains = 1 lb. avoirdupois	3·84509 80400 14256 8
(86)	277·273843570 = 70000 ÷ 252·458 = number of cubic inches in the imperial gallon.	2·44290 89026 50353 6
(87)	$\sqrt{277\cdot273843570} = 16\cdot651541777565$	1·22145 44513 25176 8
(88)	$\sqrt{\frac{277\cdot273843570}{\cdot7853981633974483}} = 18\cdot789252841825$	1·27390 95106 42091 0
(89)	$\frac{1}{277\cdot273843570} = \cdot00360\ 65428\ 57143\ 11166$	7·55709 10973 49646 4—10
(90)	231 = the number of inches in the old wine gallon	2·36361 19798 92144 3
(91)	$\sqrt{231} = 15\cdot19868\ 41535\ 706636$	1·18180 59899 46072 2
(92)	$\sqrt{\frac{231}{\cdot785398,\ \&c.}} = 17\cdot14987\ 85661\ 54$	1·23426 10492 62986 4
(93)	282 = the number of cubic inches in the old beer gallon	2·45024 91083 19361 1
(94)	$\sqrt{282} = 16\cdot79285\ 56237\ 466$	1·22512 45541 59680 5
(95)	$\sqrt{\frac{282}{\cdot785398,\ \&c.}} = 18\cdot94870\ 84418\ 78$	1·27757 96134 76594 8
(96)	Common logarithm of 10 = 1.	
(97)	$k = 2\cdot30258\ 50929\ 94045\ 68401\ 79914\ 54684\ 364$; Napier's logarithm of 10 (*compared with Wolfram and Abraham Sharp*).	
(98)	$\frac{1}{k} = 0\cdot43429\ 44819\ 03251\ 82765\ 11289\ 18916\ 605$ (*compared with Wolfram and Abraham Sharp*) = common logarithm of	
(99)	2·71828 18284 59045 23536 02874 71352 6 *Napier's* logarithm of this number = 1.	

(*compared with the same in the Life of Napier by David Stewart, Earl of Buchan, and Walter Minto, LL.D., Edition of* 1787, p. 112.)

NUMBERS.	AUTHORITIES.
(100) 0·513074 of the toise of Peru = 1 metre.....	(*Commission des poids et mesures le 11 Floréal, an 7. Delambre Base du Système Métrique.* Tom. iii. p. 432.)
(101) 1 metre = 39·370089 English inches	(*Report by Francis Baily, Esq., in Mem. of the Roy. Astron. Society of London*, Vol. ix. p. 133.)
(102) 76·733744 (= 39370089 ÷ 513074) English inches = toise of Peru	(*computed from the preceding.*)
(103) Equatorial radius of the earth = 3272077·14 toises = 251078730 English inches = 20923227·5 feet English whence 7925·465 English geographical miles = equatorial diameter	(*Toise Measure, by Bessel, Astronomische Nachrichten*, 1841, No. 438, p. 116.)
(104) Polar radius of the earth = 3261139·33 toises = 250239431 English inches = 20853285 9 English feet whence 7898 972 English geographical miles = polar diameter	(*Toise measure, by Bessel, as above.*)
(105) 299·153 polar radii = 298·153 equatorial radii.	
(106) 1·901306 cubic inches of water at the temperature of 62° Fahrenheit weigh 1 oz. troy, or 480 grs.	(1·901306 = 480 ÷ 252·458.)
(107) 1·732962 cubic inches of water weigh 1 oz. avoirdupois, or 437½ grs. at 62° of Fahrenheit	(1·732961 = 437·5 ÷ 252·458.)
(108) 1 cubic foot of air weighs 528·367 grains.	
(109) 100 of a square metre = 1 *are* = 1076·391602686 square feet = 119·599066965 sq. yards	(*deduced from No.* 101.)
(110) 1 stere = cubic metre = 35·314694 cubic feet = 1·30795164187 cubic yards.	(*deduced from No.* 101.)
(111) 1 litre = $\frac{1}{1000}$ of a cubic metre = 61·0237918 cubic inches = ·22008492 imperial gallon = 1·76067936 imperial pints	(*cubic inches, deduced from No.* 101; *gallons* = [1·1·023, &c. × 252·458) ÷ 70000].)
(112) 1 gramme = 15·434 grains.	(*from weighings made at the Mint, London, and the Bureau des Poids et Mesures, Paris.*)
(113) 1 metrical quintal = 100000 grammes = 1543400 grains = 220$\frac{17}{35}$ lbs. avoirdupois	(*deduced from No.* 112.)
(114) 1 franc = 9·52 pence.....	(*by relative value of gold and copper, London and Paris Mints.*)

THE FOLLOWING QUANTITIES VARY FROM TIME TO TIME.

1 Julian year the unit of time; and t = number of Julian years from the commencement of 1800.

(115)	Precession	= * ∓ 50″·2235 t − 0″·0001221805 t² ∓ 0″·000000000215 t³ (*Bessel, Astron. Nachrich.* 92, Feb. 1826).
(116)	Relative velocity to the equinoxes	= 1296027″·566391 ± 0″·000244361 t + 0″·000000000645 t².
(117)	Equinoxial or tropical year	= 473364000 divided by the preceding velocity. = 365·24223 11650 05 days ∓ t × 0·00000 00688 67 days. = 365*d.* 5*h.* 48*m.* 48·7727*s.* ∓ t × 0·00595*s.*
(118)	Tropical velocity of solar perigee	= 61″·5171 ± 0″·000407593 t (*Bessel. Ast. Nach.* Nos. 83 and 92).
(119)	Velocity of mean anomaly of the sun	= 1295966″·049291 ∓ 0″·000163232 t.
(120)	Anomalistic year	= 473364000 ÷ by the preceding velocity. = 365·25956 85349 70 days ± t × 0 00000 00460 06 days. = 365*d.* 6*h.* 13*m.* 46·7214*s.* ± t × 0·00397 49*s.*
(121)	Sidereal lunar velocity	= 17325593″·3925 ± 0·217572 t + 0″·00047943 t² (*Damoiseau* [*Tables de la Lune*, 2nd edit. fol. 1825] *and Bessel*).
(122)	Sidereal month	= 473364000 ÷ by the preceding velocity. = 27·32166 16177 24 days ∓ t × 0·00000 03431 01 days. = 27*d.* 7*h.* 43*m.* 11·5638*s.* ∓ t × 0·02964*s.*
(123)	Tropical lunar velocity	= 17325643″·616 ± 0″·217816 t + 0″·00047943 t² (*Damoiseau*).
(124)	Tropical month	= 473364000 ÷ by the preceding velocity. = 27·32158 24180 32 days ∓ t × 0·00000 03434 84 days. = 27*d.* 7*h.* 43*m.* 4·7209*s.* ∓ t × 0·02968*s.*
(125)	Synodic lunar velocity	= 16029616″·049609 ± 0″·217572 t.
(126)	Synodic month	= 473364000 ÷ by the preceding velocity. = 29·53058 87885 91 days ∓ t × 0·00000 04008 21 days. = 29*d.* 12*h.* 44*m.* 2·8713*s.* ∓ t × 0·03463*s.*

* When two signs occur, the *upper* is for time *after* the beginning of the year 1800, and the *lower* for time *before* 1800.

QUANTITIES VARYING FROM TIME TO TIME—*continued.*

(127)	Velocity of moon's mean anomaly	= 17179157″·95 ± 1″·008406 t + 0″·00273105 t² (*Damoiseau*).
(128)	Anomalistic month	= 27·55455 19389 09 days ∓ t × 0·00000 16174 36 days. = 27*d*. 13*h*. 18*m*. 33·2875*s*. ∓ t × 0·139746*s*.
(129)	Velocity of moon from node	= 17395273″·591 ± 0″·086308 t + 0″·12393 t² (*Damoiseau*).
(130)	Draconic month.....	= 473364000 ÷ by the preceding velocity. = 27·21221 93148 44 days ∓ t × 0·00000 01350 16 days. = 27*d*. 5*h*. 5*m*. 35·7488*s*. ∓ t × 0·01166 5*s*.
(131)	Sidereal velocity of lunar perigee	= 146435″·4425 ± 0″·790834 t (*Damoiseau and Bessel*).
(132)	Sidereal period of lunar perigee.....	= 473364000 ÷ by the preceding velocity. = 3232·57806 93427 41 days ∓ t × 0 01754 74577 48 days. = 3232*d*. 13*h*. 52*m*. 25·1912*s*. ∓ t × 25*m*. 8·3494*s*.
(133)	Tropical velocity of lunar perigee	= 146485″·666 ∓ 0″·79059 t − 0″·00225162 t² (*Damoiseau*).
(134)	Tropical period of the lunar perigee.....	= 473364000 ÷ by the preceding velocity. = 3231·46976 03245 36 days + t × 0·01744 03936 41 days. = 3231*d*. 11*h*. 16*m*. 27·29204*s*. + t × 25*m*. 6·85*s*.
(135)	Sidereal velocity of the moon's node	= − 69680″·1985 + 0″·131264 t (*Damoiseau and Bessel*).
(136)	Sidereal period of the node.....	= 473364000 ÷ by the preceding velocity. = 6793·37904 01147 16 days ± t × 0·01279 74105 days. = 6793*d*. 9*h*. 5*m*. 49·0659*s*. ± t × 18*m*. 25·69627*s*.
(137)	Tropical velocity of the moon's node	= − 69629″·975 + 0″·131508 t + 0″·0003555 t² (*Damoiseau*).
(138)	Tropical period of the node	= 6798·27904 57701 59 days ± t × 0·01283 97073 days. = 6798*d*. 6*h*. 41*m*. 49·5545*s*. ± t × 18*m*. 29·2907*s*.
(139)	Inequality of long period (240 years) in the sun's longitude, discovered by G. B. Airy, Esq., Astronomer Royal (Phil. Trans. of Roy. Soc. of London, 1832, Part ii. p. 67).	= (2″·049 − 0″·0002076 t) sin (2 8° 43′ 37″ + t × 1° 30′ 15″·118). *Airy, Bissel, Lindenau.*)

APPENDIX.

TABLE I.

CONTAINING THE

CIRCUMFERENCES AND AREAS OF CIRCLES,

SIDES OF EQUAL SQUARES

SQUARES AND CUBES OF THE DIAMETERS,

FROM $\frac{1}{8}th$ TO 100 INCHES, FEET, YARDS, CHAINS, MILES, &c. ADVANCING BY AN $\frac{1}{8}th$, AND ALSO THE SIDE OF EQUAL SQUARE, ADVANCING AT AN EQUAL RATIO.

TABLE I.

Dia. or Root.	Circum.	Area.	Side of = square.	Square.	Cube.
⅛	0·3927	0·0123	0·1108	0·0156	0·00195
¼	0·7854	0·0491	0·2216	0·0625	0·01563
⅜	1·1781	0·1104	0·3323	0·1406	0·05273
½	1·5708	0·1963	0·4431	0·25	0·125
⅝	1·9635	0·3068	0·5539	0·3906	0·24414
¾	2·3562	0·4418	0·6647	0·5625	0·42188
⅞	2·7489	0·6013	0·7754	0·7656	0·66992
1 *in.*	3·1416	0·7854	0·8862	1·	1·
⅛	3·5343	0·9940	0·9970	1·2656	1·42383
¼	3·9270	1·2272	1·1078	1·5625	1·95313
⅜	4·3197	1·4849	1·2186	1·8906	2·59961
½	4·7124	1·7671	1·3293	2·25	3·375
⅝	5·1051	2·0739	1·4401	2·6406	4·29102
¾	5·4978	2·4053	1·5509	3·0625	5·35938
⅞	5·8905	2·7612	1·6617	3·5156	6·59180
2 *in.*	6·2832	3·1416	1·7725	4·	8·
⅛	6·6759	3·5466	1·8832	4·5156	9·5957
¼	7·0686	3·9761	1·9940	5·0625	11·3906
⅜	7·4613	4·4301	2·1048	5·6406	13·3965
½	7·8540	4·9087	2·2156	6·25	15·625
⅝	8·2467	5·4119	2·3263	6·8906	18·0879
¾	8·6394	5·9396	2·4371	7·5625	20·7969
⅞	9·0321	6·4918	2·5479	8·2656	23·7637
3 *in.*	9·4248	7·0686	2·6587	9·	27·
⅛	9·8175	7·6699	2·7695	9·7656	30·5176
¼	10·2102	8·2958	2·8802	10·5625	34·3281
⅜	10·6029	8·9462	2·9910	11·3906	38·4434
½	10·9956	9·6211	3·1018	12·25	42·875
⅝	11·3883	10·3206	3·2126	13·1406	47·6348
¾	11·7810	11·0447	3·3234	14·0625	52·7344
⅞	12·1737	11·7932	3·4341	15·0156	58·1855
4 *in.*	12·5664	12·5664	3·5449	16·	64·
⅛	12·9591	13·3640	3·6557	17·0156	70·1895
¼	13·3518	14·1863	3·7665	18·0625	76·7656
⅜	13·7445	15·0330	3·8772	19·1406	83·7402
½	14·1372	15·9043	3·9880	20·25	91·125
⅝	14·5299	16·8002	4·0988	21·3906	98·9316
¾	14·9226	17·7205	4·2096	22·5625	107·1719
⅞	15·3153	18·6655	4·3204	23·7656	115·8574
5 *in.*	15·7080	19·6350	4·4311	25·	125·
⅛	16·1007	20·6290	4·5419	26·2656	134·6113
¼	16·4934	21·6475	4·6527	27·5625	144·7031
⅜	16·8861	22·6906	4·7635	28·8906	155·2871
½	17·2788	23·7583	4·8742	30·25	166·375
⅝	17·6715	24·8505	4·9850	31·6406	177·9785
¾	18·0642	25·9672	5·0958	33·0625	190·1094
⅞	18·4569	27·1085	5·2066	34·5156	202·7793

TABLE I.

Dia. or Root.	Circum.	Area.	Side of = square.	Square.	Cube.
6 *in.*	18·8496	28·2743	5·3174	36·	216·
⅛	19·2423	29·4647	5·4281	37·5156	229·7832
¼	19·6350	30·6796	5·5389	39·0625	244·1406
⅜	20·0277	31·9191	5·6497	40·6406	259·0840
½	20·4204	33·1831	5·7605	42·25	274·625
⅝	20·8131	34·4716	5·8713	43·8906	290·7754
¾	21·2058	35·7847	5·9820	45·5625	307·5469
⅞	21·5985	37·1223	6·0928	47·2656	324·9512
7 *in.*	21·9912	38·4846	6·2036	49·	343·
⅛	22·3839	39·8712	6·3144	50·7656	361·7051
¼	22·7766	41·2825	6·4251	52·5625	381·0781
⅜	23·1693	42·7183	6·5359	54·3906	401·1309
½	23·5620	44·1786	6·6467	56·25	421·875
⅝	23·9547	45·6635	6·7575	58·1406	443·3223
¾	24·3474	47·1730	6·8683	60·0625	465·4844
⅞	24·7401	48·7070	6·9790	62·0156	488·3730
8 *in.*	25·1328	50·2655	7·0898	64·	512·
⅛	25·5255	51·8486	7·2006	66·0156	536·3770
¼	25·9182	53·4562	7·3114	68·0625	561·5156
⅜	26·3109	55·0883	7·4222	70·1406	587·4277
½	26·7036	56·7450	7·5329	72·25	614·125
⅝	27·0963	58·4263	7·6437	74·3906	641·6191
¾	27·4890	60·1320	7·7545	76·5625	669·9219
⅞	27·8817	61·8624	7·8653	78·7656	699·0449
9 *in.*	28·2743	63·6173	7·9760	81·	729·
⅛	28·6670	65·3967	8·0868	83·2656	759·7988
¼	29·0597	67·2006	8·1976	85·5625	791·4531
⅜	29·4524	69·0291	8·3084	87·8906	823·9746
½	29·8451	70·8822	8·4192	90·25	857·375
⅝	30·2378	72·7598	8·5299	92·6406	891·6660
¾	30·6305	74·6619	8·6407	95·0625	926·8594
⅞	31·0232	76·5886	8·7515	97·5156	962·9668
10 *in.*	31·4159	78·5398	8·8623	100·	1000·
⅛	31·8086	80·5156	8·9730	102·5156	1037·9707
¼	32·2013	82·5159	9·0838	105·0625	1076·8906
⅜	32·5940	84·5407	9·1946	107·6406	1116·7715
½	32·9867	86·5901	9·3054	110·25	1157·625
⅝	33·3794	88·664	9·4162	112·8906	1199·4629
¾	33·7721	90·7626	9·5269	115·5625	1242·2969
⅞	34·1648	92·8856	9·6377	118·2656	1286·1387
11 *in.*	34·5575	95·0332	9·7485	121·	1331·
⅛	34·9502	97·2053	9·8593	123·7656	1376·8926
¼	35·3429	99·4020	9·9701	126·5625	1423·8281
⅜	35·7356	101·6232	10·0808	129·3906	1471·8184
½	36·1283	103·8689	10·1916	132·25	1520·875
⅝	36·5210	106·1392	10·3024	135·1406	1571·0098
¾	36·9137	108·4340	10·4132	138·0625	1622·2344
⅞	37·3064	110·7534	10·5239	141·0156	1674·5605

TABLE I.

Dia. or Root.	Circum.	Area.	Side of = square.	Square.	Cube.
12 *in.*	37·6991	113·0973	10·6347	144·	1728·
⅛	38·0918	115·4658	10·7455	147·0156	1782·5645
¼	38·4845	117·8588	10·8563	150·0625	1838·2656
⅜	38·8772	120·2764	10·9671	153·1406	1895·1152
½	39·2699	122·7185	11·0778	156·25	1953·1250
⅝	39·6626	125·1851	11·1886	159·3906	2012·3066
¾	40·0553	127·6763	11·2994	162·5625	2072·6719
⅞	40·4480	130·1920	11·4102	165·7656	2134·2324
13 *in.*	40·8407	132·7323	11·5210	169·	2197·
⅛	41·2334	135·2971	11·6317	172·2656	2260·9863
¼	41·6261	137·8865	11·7425	175·5625	2326·2031
⅜	42·0188	140·5004	11·8533	178·8906	2392·6621
½	42·4115	143·1388	11·9641	182·25	2460·3750
⅝	42·8042	145·8018	12·0748	185·6406	2529·3535
¾	43·1969	148·4893	12·1856	189·0625	2599·6094
⅞	43·5896	151·2014	12·2964	192·5156	2671·1543
14 *in.*	43·9823	153·9380	12·4072	196·	2744·
⅛	44·3750	156·6992	12·5180	199·5156	2818·1582
¼	44·7677	159·4849	12·6287	203·0625	2893·6406
⅜	45·1504	162·2952	12·7395	206·6406	2970·4590
½	45·5531	165·1300	12·8503	210·25	3048·6250
⅝	45·9458	167·9893	12·9611	213·8906	3128·1504
¾	46·3385	170·8732	13·0718	217·5625	3209·0469
⅞	46·7312	173·7816	13·1826	221·2656	3291·3262
15 *in.*	47·1239	176·7146	13·2934	225·	3375·
⅛	47·5166	179·6721	13·4042	228·7656	3460·0801
¼	47·9093	182·6542	13·5150	232·5625	3546·5781
⅜	48·3020	185·6608	13·6257	236·3906	3634·5059
½	48·6947	188·6919	13·7365	240·25	3723·8750
⅝	49·0874	191·7476	13·8473	244·1406	3814·6973
¾	49·4801	194·8278	13·9581	248·0625	3906·9844
⅞	49·8728	197·9326	14·0689	252·0156	4000·7480
16 *in.*	50·2655	201·0619	14·1796	256·	4096·
⅛	50·6582	204·2158	14·2904	260·0156	4192·7520
¼	51·0509	207·3942	14·4012	264·0625	4291·0156
⅜	51·4436	210·5972	14·5120	268·1406	4390·8027
½	51·8363	213·8246	14·6227	272·25	4492·1250
⅝	52·2290	217·0767	14·7335	276·3906	4594·9941
¾	52·6217	220·3533	14·8443	280·5625	4699·4219
⅞	53·0144	223·6544	14·9551	284·7656	4805·4199
17 *in.*	53·4071	226·9801	15·0659	289·	4913·
⅛	53·7998	230·3303	15·1766	293·2656	5022·1738
¼	54·1925	233·7050	15·2874	297·5625	5132·9531
⅜	54·5852	237·1044	15·3982	301·8906	5245·3496
½	54·9779	240·5282	15·5090	306·25	5359·3750
⅝	55·3706	243·9766	15·6197	310·6406	5475·0410
¾	55·7633	247·4495	15·7305	315·0625	5592·3594
⅞	56·1560	250·9470	15·8413	319·5156	5711·3418

TABLE I.

Dia. or Root.	Circum.	Area.	Side of = square.	Square.	Cube.
18 *in.*	56·5487	254·4690	15·9521	324·	5832·
⅛	56·9414	258·0159	16·0629	328·5156	5954·3457
¼	57·3341	261·5867	16·1736	333·0625	6078·3906
⅜	57·7268	265·1824	16·2844	337·6406	6204·1465
½	58·1195	268·8025	16·3952	342·25	6331·6250
⅝	58·5122	272·4473	16·5060	346·8906	6460·8379
¾	58·9049	276·1165	16·6168	351·5625	6591·7969
⅞	59·2976	279·8104	16·7275	356·2656	6724·5137
19 *in.*	59·6903	283·5287	16·8383	361·	6859·
⅛	60·0830	287·2717	16·9491	365·7656	6995·2676
¼	60·4757	291·0599	17·0599	370·5625	7133·3281
⅜	60·8684	294·8311	17·1706	375·3906	7273·1934
½	61·2611	298·6477	17·2814	380·25	7414·8750
⅝	61·6538	302·4887	17·3922	385·1406	7558·3848
¾	62·0465	306·3544	17·5030	390·0625	7703·7344
⅞	62·4392	310·2446	17·6138	395·0156	7850·9355
20 *in.*	62·8319	314·1593	17·7245	400·	8000·
⅛	63·2245	318·0985	17·8353	405·0156	8150·9395
¼	63·6173	322·0623	17·9461	410·0625	8303·7656
⅜	64·0100	326·0507	18·0569	415·1406	8458·4902
½	64·4026	330·0636	18·1677	420·25	8615·1250
⅝	64·7953	334·1010	18·2784	425·3906	8773·6816
¾	65·1880	338·1630	18·3892	430·5625	8934·1719
⅞	65·5807	342·2495	18·5000	435·7656	9096·6074
21 *in.*	65·9734	346·3606	18·6108	441·	9261·
⅛	66·3661	350·4962	18·7215	446·2656	9427·3613
¼	66·7588	354·6564	18·8323	451·5625	9595·7031
⅜	67·1515	358·8411	18·9431	456·8906	9766·0371
½	67·5442	363·0503	19·0539	462·25	9938·3750
⅝	67·9369	367·2841	19·1647	467·6406	10112·7285
¾	68·3296	371·5424	19·2754	473·0625	10289·1094
⅞	68·7223	375·8253	19·3862	478·5156	10467·5293
22 *in.*	69·1150	380·1327	19·4970	484·	10648·
⅛	69·5077	384·4647	19·6078	489·5156	10830·5332
¼	69·9004	388·8212	19·7185	495·0625	11015·1406
⅜	70·2931	393·2022	19·8293	500·6406	11201·8340
½	70·6858	397·6078	19·9401	506·25	11390·6250
⅝	71·0785	402·0380	20·0509	511·8906	11581·5254
¾	71·4712	406·4926	20·1617	517·5625	11774·5469
⅞	71·8639	410·9719	20·2724	523·2656	11969·7012
23 *in.*	72·2566	415·4756	20·3832	529·	12167·
⅛	72·6493	420·0039	20·4940	534·7656	12366·4551
¼	73·0420	424·5568	20·6048	540·5625	12568·0781
⅜	73·4347	429·1342	20·7156	546·3906	12771·8809
½	73·8274	433·7361	20·8263	552·25	12977·8750
⅝	74·2201	438·3626	20·9371	558·1406	13186·0723
¾	74·6128	443·0137	21·0479	564·0625	13396·4844
⅞	75·0055	447·6892	21·1587	570·0156	13609·1230

TABLE I.

Dia. or Root.	Circum.	Area.	Side of = square.	Square.	Cube.
24 *in.*	75·3982	452·3893	21·2694	576·	13824·
⅛	75·7909	457·1140	21·3802	582·0156	14041·1270
¼	76·1836	461·8632	21·4910	588·0625	14260·5156
⅜	76·5763	466·6370	21·6018	594·1406	14482·1777
½	76·9690	471·4352	21·7126	600·25	14706·125
⅝	77·3617	476·2581	21·8233	606·3906	14932·3691
¾	77·7544	481·1055	21·9341	612·5625	15160·9219
⅞	78·1471	485·9774	22·0449	618·7656	15391·7949
25 *in.*	78·5398	490·8739	22·1557	625·	15625·
⅛	78·9325	495·7949	22·2665	631·2656	15860·5488
¼	79·3252	500·7404	22·3772	637·5625	16098·4531
⅜	79·7179	505·7105	22·4880	643·8906	16338·7246
½	80·1106	510 7052	22·5988	650·25	16581·375
⅝	80·5033	515·7243	22·7096	656·6406	16826·4160
¾	80·8960	520·7681	22·8203	663·0625	17073·8594
⅞	81·2887	525 8363	22·9311	669·5156	17323·7168
26 *in.*	81·6814	530·9292	23·0419	676·	17576·
⅛	82·0741	536·0465	23·1527	682·5156	17830·7207
¼	82·4668	541·1884	23·2635	689·0625	18087·8906
⅜	82·8595	546·3549	23·3742	695·6406	18347·5215
½	83·2522	551·5459	23·4850	702·25	18069·625
⅝	83·6449	556·7614	23·5958	708·8906	18874·2129
¾	84·0376	562·0015	23·7066	715·5625	19141·2969
⅞	84·4303	567·2661	23·8173	722·2656	19410·8887
27 *in.*	84·8230	572·5553	23·9281	729·	19683·
⅛	85·2157	577·8690	24·0389	735·7656	19957·6426
¼	85·6084	583·2072	24·1497	742·5625	20234·8281
⅜	86·0011	588·5700	24·2605	749·3906	20514·5684
½	86·3938	593·9574	24·3712	756·25	20796·875
⅝	86·7865	599·3692	24·4820	763·1406	21081·7598
¾	87·1792	604·8057	24·5928	770·0625	21369·2344
⅞	87·5719	610·2666	24·7036	777·0156	21659·3105
28 *in.*	87·9646	615·7522	24·8144	784·	21952·
⅛	88·3573	621·2622	24·9251	791·0156	22247·3145
¼	88·7500	626·7968	25·0359	798·0625	22545·2656
⅜	89·1427	632·3560	25·1467	805·1406	22845·8652
½	89·5354	637·9397	25·2575	812·25	23149·125
⅝	89·9281	643·5479	25·3682	819·3906	23455·0566
¾	90·3208	649·1807	25·4790	826·5625	23763·6719
⅞	90·7135	654·8380	25·5898	833·7656	24074·9824
29 *in.*	91·1062	660·5199	25·7006	841·	24389·
⅛	91·4989	666·2263	25·8114	848·2656	24705·7363
¼	91·8916	671·9572	25·9221	855·5625	25025·2031
⅜	92·2843	677·7127	26·0329	862·8906	25347·4121
½	92·6770	683·4928	26·1437	870·25	25672·375
⅝	93·0697	689·2973	26·2545	877·6406	26000·1035
¾	93·4624	695·1265	26·3653	885·0625	26330·6094
⅞	93·8551	700·9801	26·4760	892·5156	26663·9043

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Dia. or Root.	Circum.	Area.	Side of = square.	Square.	Cube.
30 *in.*	94·2478	706·8583	26·5868	900·	27000·
⅛	94·6405	712·7611	26·6976	907·5156	27338·9082
¼	95·0332	718·6884	26·8084	915·0625	27680·6406
⅜	95·4259	724·6403	26·9191	922·6406	28025·2090
½	95·8186	730·6166	27·0299	930·25	28372·625
⅝	96·2113	736·6176	27·1407	937·8906	28722·9004
¾	96·6040	742·6431	27·2515	945·5625	29076·0469
⅞	96·9967	748·6931	27·3623	953·2656	29432·0762
31 *in.*	97·3894	754·7676	27·4730	961·	29791·
⅛	97·7821	760·8667	27·5838	968·7656	30152·8301
¼	98·1748	766·9904	27·6946	976·5625	30517·5781
⅜	98·5675	773·1386	27·8054	984·3906	30885·2559
½	98·9602	779·3113	27·9161	992·25	31255·875
⅝	99·3529	785·5086	28·0269	1000·1406	31629·4473
¾	99·7456	791·7304	28·1377	1008·0625	32005·9844
⅞	100·1383	797·9768	28·2485	1016·0156	32385·4980
32 *in.*	100·5310	804·2477	28·3593	1024·	32768·
⅛	100·9237	810·5432	28·4700	1032·0156	33153·5020
¼	101·3164	816·8632	28·5808	1040·0625	33542·0156
⅜	101·7091	823·2077	28·6916	1048·1406	33933·5527
½	102·1018	829·5768	28·8024	1056·25	34328·125
⅝	102·4945	835·9704	28·9132	1064·3906	34725·7441
¾	102·8872	842·3886	29·0239	1072·5625	35126·4219
⅞	103·2799	848·8313	29·1347	1080·7656	35530·1699
33 *in.*	103·6726	855·2986	29·2455	1089·	35937·
⅛	104·0653	861·7904	29·3563	1097·2656	36346·9238
¼	104·4580	868·3068	29·4670	1105·5625	36759·9531
⅜	104·8507	874·8477	29·5778	1113·8906	37176·0996
½	105·2434	881·4131	29·6886	1122·25	37595·375
⅝	105·6361	888·0031	29·7994	1130·6406	38017·7910
¾	106·0288	894·6176	29·9102	1139·0625	38443·3594
⅞	106·4215	901·2576	30·0209	1147·5156	38872·0918
34 *in.*	106·8142	907·9203	30·1317	1156·	39304·
⅛	107·2068	914·6084	30·2425	1164·5156	39739·0957
¼	107·5995	921·3211	30·3533	1173·0625	40177·3906
⅜	107·9922	928·0584	30·4641	1181·6406	40618·8965
½	108·3849	934·8202	30·5748	1190·25	41063 625
⅝	108·7776	941·6065	30·6856	1198·8906	41511·5879
¾	109·1703	948·4174	30·7964	1207·5625	41962·7969
⅞	109·5630	955·2528	30·9072	1216·2656	42417·2636
35 *in.*	109·9557	962·1128	31·0179	1225·	42875·
⅛	110·3484	968·9973	31·1287	1233·7656	43336·0176
¼	110·7411	975·9063	31·2395	1242·5625	43800·3281
⅜	111·1338	982·8399	31·3503	1251·3906	44267·9433
½	111·5265	989·7980	31·4611	1260·25	44738·875
⅝	111·9192	996·7807	31·5718	1269·1406	45213·1348
¾	112·3119	1003·7879	31·6826	1278·0625	45690·7344
⅞	112·7046	1010·8197	31·7934	1287·0156	46171·6855

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Dia. or Root.	Circum.	Area.	Side of = square.	Square.	Cube.
36 *in.*	113·0973	1017·8760	31·9042	1296·	46656·
⅛	113·4900	1024·9569	32·0149	1305·0156	47143·6895
¼	113·8827	1032·0623	32·1257	1314·0625	47634·7656
⅜	114·2754	1039·1922	32·2365	1323·1406	48129·2402
½	114·6681	1046·3467	32·3473	1332·25	48627·125
⅝	115·0608	1053·5257	32·4581	1341·3906	49128·4316
¾	115·4535	1060·7293	32·5688	1350·5625	49633·1719
⅞	115·8462	1067·9574	32·6796	1359·7656	50141·3574
37 *in.*	116·2389	1075·2101	32·7904	1369·	50653·
⅛	116·6316	1082·4873	32·9012	1378·2656	51168·1113
¼	117·0243	1089·7890	33·0120	1387·5625	51686·7031
⅜	117·4170	1097·1153	33·0227	1396·8906	52208·7871
½	117·8097	1104·4662	33·2335	1406·25	52734·375
⅝	118·2024	1111·8415	33·3443	1415·6406	53263·4785
¾	118·5951	1119·2415	33·4551	1425·0625	53796·1094
⅞	118·9878	1126·6659	33·5658	1434·5156	54332·2793
38 *in.*	119·3805	1134·1149	33·6766	1444·	54872·
⅛	119·7732	1141·5885	33·7874	1453·5156	55415·2832
¼	120·1659	1149·0866	33·8982	1463·0625	55962·1406
⅜	120·5586	1156·6092	34·0090	1472·6406	56512·5839
½	120·9513	1164·1564	34·1197	1482·25	57066·625
⅝	121·3440	1171·7282	34·2305	1491·8906	57624·2754
¾	121·7367	1179·3244	34·3413	1501·5625	58185·5469
⅞	122·1294	1186·9452	34·4521	1511·2656	58750·4512
39 *in.*	122·5221	1194·5906	34·5629	1521·	59319·
⅛	122·9148	1202·2605	34·6736	1530·7656	59891·2051
¼	123·3075	1209·9550	34·7844	1540·5625	60467·0781
⅜	123·7002	1217·6739	34·8952	1550·3906	61046·6309
½	124·0929	1225·4175	35·0060	1560·25	61629·875
⅝	124·4856	1233·1855	35·1167	1570·1406	62216·8223
¾	124·8783	1240·9782	35·2275	1580·0625	62807·4844
⅞	125·2710	1248·7954	35·3383	1590·0156	63401·8730
40 *in.*	125·6637	1256·6370	35·4491	1600·	64000·
⅛	126·0564	1264·5033	35·5599	1610·0156	64601·8770
¼	126·4491	1272·3941	35·6706	1620·0625	65207·5156
⅜	126·8418	1280·3095	35·7814	1630·1406	65816·9277
½	127·2345	1288·2493	35·8922	1640·25	66430·125
⅝	127·6272	1296·2138	36·0030	1650·3906	67047·1191
¾	128·0199	1304·2027	36·1137	1660·5625	67667·9219
⅞	128·4126	1312·2163	36·2245	1670·7656	68292·5449
41 *in.*	128·8053	1320·2543	36·3353	1681·	68921·
⅛	129·1980	1328·3169	36·4461	1691·2656	69553·2988
¼	129·5907	1336·4041	36·5569	1701·5625	70189·4531
⅜	129·9834	1344·5158	36·6676	1711·8906	70829·4746
½	130·3761	1352·6520	36·7784	1722·25	71473·375
⅝	130·7688	1360·8128	36·8892	1732·6406	72121·1660
¾	131·1615	1368·9981	37·0000	1743·0625	72772·8594
⅞	131·5542	1377·2080	37·1108	1753·5156	73428·4668

TABLE I.

Dia. or Root.	Circum.	Area.	Side of = square.	Square.	Cube.
42 *in.*	131·9469	1385·4424	37·2215	1764·	74088·
⅛	132·3396	1393·7013	37·3323	1774·5156	74751·4707
¼	132·7323	1401·9848	37·4431	1785·0625	75418·8906
⅜	133·1250	1410·2928	37·5539	1795·6406	76090·2715
½	133·5177	1418·6254	37·6646	1806·25	76765·625
⅝	133·9104	1426·9826	37·7754	1816·8906	77444·9629
¾	134·3031	1435·3642	37·8862	1827·5625	78128·2969
⅞	134·6958	1443·7704	37·9970	1838·2656	78815·6387
43 *in.*	135·0885	1452·2012	38·1078	1849·	79507·
⅛	135·4812	1460·6565	38·2185	1859·7656	80202·3926
¼	135·8739	1469·1364	38·3293	1870·5625	80901·8281
⅜	136·2666	1477·6407	38·4401	1881·3906	81605·3183
½	136·6593	1486·1697	38·5509	1892·25	82312·875
⅝	137·0520	1494·7232	38·6616	1903·1406	83024·5097
¾	137·4447	1503·3012	38·7724	1914·0625	83740·2344
⅞	137·8374	1511·9037	38·8832	1925·0156	84460·0605
44 *in.*	138·2301	1520·5308	38·9940	1936·	85184·
⅛	138·6228	1529·1825	39·1048	1947·0156	85912·0644
¼	139·0155	1537·8587	39·2155	1958·0625	86644·2656
⅜	139·4082	1546·5594	39·3263	1969·1406	87380·6152
½	139·8009	1555·2847	39·4371	1980·25	88121·125
⅝	140·1936	1564·0345	39·5479	1991·3906	88865·8066
¾	140·5863	1572·8089	39·6587	2002·5625	89614·6719
⅞	140·9790	1581·6078	39·7694	2013·7656	90367·7324
45 *in.*	141·3717	1590·4313	39·8802	2025·	91125·
⅛	141·7644	1599·2793	39·9910	2036·2656	91886·4863
¼	142·1571	1608·1518	40·1018	2047·5625	92652·2031
⅜	142·5498	1617·0489	40·2125	2058·8906	93422·1621
½	142·9425	1625·9705	40·3233	2070·25	94196·375
⅝	143·3352	1634·9167	40·4341	2081·6406	94974·8535
¾	143·7279	1643·8874	40·5449	2093·0625	95757·6094
⅞	144·1206	1652·8827	40·6557	2104·5156	96544·6543
46 *in.*	144·5133	1661·9025	40·7664	2116·	97336·
⅛	144·9060	1670·9469	40·8772	2127·5156	98131·6582
¼	145·2987	1680·0158	40·9880	2139·0625	98931·6406
⅜	145·6914	1689·1092	41·0988	2150·6406	99735·9589
½	146·0841	1698·2272	41·2096	2162·25	100544·625
⅝	146·4768	1707·3697	41·3203	2173 8906	101357·6504
¾	146·8695	1716·5368	41·4311	2185·5625	102175·0469
⅞	147·2622	1725·7284	41·5419	2197·2656	102996·8261
47 *in.*	147·6549	1734·9445	41·6527	2209·	103823·
⅛	148·0476	1744·1852	41·7634	2220·7656	104653·5800
¼	148·4403	1753·4505	41·8742	2232·5625	105488·5781
⅜	148·8329	1762·7403	41·9850	2244·3906	106328·0058
½	149·2257	1772·0546	42·0958	2256·25	107171·875
⅝	149·6183	1781·3935	42·2066	2268·1406	108020·1973
¾	150·0110	1790·7569	42·3173	2280·0625	108872·9844
⅞	150·4037	1800·1449	42·4281	2292·0156	109730·2480

TABLE I.

Dia. or Root.	Circum.	Area.	Side of = square.	Square.	Cube.
48 *in.*	150·7964	1809·5574	42·5389	2304·	110592·
⅛	151·1891	1818·9944	42·6497	2316·0156	111458·2520
¼	151·5818	1828·4560	42·7604	2328·0625	112329·0156
⅜	151·9745	1837·9421	42·8712	2340·1406	113204·3027
½	152·3672	1847·4528	42·9820	2352·25	114084·125
⅝	152·7599	1856·9881	43·0928	2364·3906	114968·4941
¾	153·1526	1866·5478	43·2036	2376·5625	115857·4219
⅞	153·5453	1876·1321	43·3143	2388·7656	116750·9199
49 *in.*	153·9380	1885·7410	43·4251	2401·	117649·
⅛	154·3307	1895·3744	43·5359	2413·2656	118551·6733
¼	154·7234	1905·0323	43·6467	2425·5625	119458·9531
⅜	155·1161	1914·7148	43·7575	2437·8906	120370·8496
½	155·5088	1924·4218	43·8682	2450·25	121287·375
⅝	155·9015	1934·1534	43·9790	2462·6406	122208·5410
¾	156·2942	1943·9095	44·0898	2475·0625	123134·3594
⅞	156·6869	1953·6902	44·2006	2487·5156	124064·8418
50 *in.*	157·0796	1963·4954	44·3113	2500·	125000·
⅛	157·4723	1973·3252	44·4221	2512·5156	125939·8457
¼	157·8650	1983·1794	44·5329	2525·0625	126884·3906
⅜	158·2577	1993·0583	44·6437	2537·6406	127833·645
½	158·6504	2002·9617	44·7545	2550·25	128787·625
⅝	159·0431	2012·8896	44·8652	2562·8906	129746·3379
¾	159·4358	2022·8421	44·9760	2575·5625	130701·7969
⅞	159·8285	2032·8191	45·0868	2588·2656	131678·0136
51 *in.*	160·2212	2042·8206	45·1976	2601·	132651·
⅛	160·6139	2052·8467	45·3084	2613·7656	133628·7676
¼	161·0066	2062·8974	45·4191	2626·5625	134611·3281
⅜	161·3993	2072·9725	45·5299	2639·3906	135598·6933
½	161·7920	2083·0723	45·6407	2652·25	136590·875
⅝	162·1847	2093·1966	45·7515	2665·1406	137587·8847
¾	162·5774	2103·3454	45·8622	2678·0625	138589·7344
⅞	162·9701	2113·5187	45·9730	2691·0156	139596·4355
52 *in.*	163·3628	2123·7166	46·0838	2704·	140608·
⅛	163·7555	2133·9391	46·1946	2717·0156	141624·435
¼	164·1482	2144·1861	46·3054	2730·0625	142645·7656
⅜	164·5409	2154·4576	46·4161	2743·1406	143671·9902
½	164·9336	2164·7537	46·5269	2756·25	144703·125
⅝	165·3263	2175·0743	46·6377	2769·3906	145739·1816
¾	165·7190	2185·4195	46·7485	2782·5625	146780·1719
⅞	166·1117	2195·7892	46·8592	2795·7656	147826·1074
53 *in.*	166·5044	2206·1834	46·9700	2809·	148877·
⅛	166·8971	2216·6022	47·0808	2822·2656	149932·8613
¼	167·2898	2227·0456	47·1916	2835·5625	150993·7031
⅜	167·6825	2237·5135	47·3024	2848·8906	152059·5371
½	168·0752	2248·0059	47·4131	2862·25	153130·375
⅝	168·4679	2258·5229	47·5239	2875·6406	154206·2285
¾	168·8606	2269·0644	47·6347	2889·0625	155287·1094
⅞	169·2533	2279·6304	47·7455	2902·5156	156373·0292

TABLE I.

Dia. or Root.	Circum.	Area.	Side of = square.	Square.	Cube.
54 *in.*	169·6460	2290·2210	47·8563	2916·	157464·
⅛	170·0387	2300·8362	47·9670	2929·5156	158560·0332
¼	170·4314	2311·4759	48·0778	2943·0625	159661·1406
⅜	170·8241	2322·1401	48·1886	2956·6406	160767·3339
½	171·2168	2332·8289	48·2994	2970·25	161878·625
⅝	171·6095	2343·5422	48·4101	2983·8906	162995·0254
¾	172·0022	2354·2801	48·5209	2997·5625	164116·5469
⅞	172·3949	2365·0425	48·6317	3011·2656	165243·2011
55 *in.*	172·7856	2375·8294	48·7425	3025·	166375·
⅛	173·1803	2386·6409	48·8533	3038·7656	167511·9550
¼	173·5730	2397·4770	48·9640	3052·5625	168654·0781
⅜	173·9657	2408·3376	49·0748	3066·3906	169801·3809
½	174·3584	2419·2227	49·1856	3080·25	170953·875
⅝	174·7511	2430·1324	49·2964	3094·1406	172111·5722
¾	175·1438	2441·0666	49·4072	3108·0625	173274·4844
⅞	175·5365	2452·0253	49·5179	3122·0156	174442·6230
56 *in.*	175·9292	2463·0086	49·6287	3136·	175616·
⅛	176·3219	2474·0165	49·7395	3150·0156	176794·6269
¼	176·7146	2485·0489	49·8503	3164·0625	177978·5156
⅜	177·1073	2496·1058	49·9610	3178·1406	179167·6777
½	177·5000	2507·1873	50·0718	3192·25	180362·125
⅝	177·8927	2518·2933	50·1826	3206·3906	181561·8691
¾	178·2854	2529·4239	50·2934	3220·5625	182766·9219
⅞	178·6781	2540·5790	50·4042	3234·7656	183977·2949
57 *in.*	179·0708	2551·7586	50·5149	3249·	185193·
⅛	179·4635	2562·9628	50·6257	3263·2656	186414·0488
¼	179·8562	2574·1916	50·7365	3277·5625	187640·4531
⅜	180·2489	2585·4449	50·8473	3291·8906	188872·2246
½	180·6416	2596·7227	50·9580	3306·25	190109·375
⅝	181·0343	2608·0250	51·0688	3320·6406	191351·9160
¾	181·4270	2619·3520	51·1796	3335·0625	192599·8594
⅞	181·8197	2630·7034	51·2904	3349·5156	193853·2168
58 *in.*	182·2124	2642·0794	51·4012	3364·	195112·
⅛	182·6051	2653·4800	51·5119	3378·5156	196376·2207
¼	182·9978	2664·9051	51·6227	3393·0625	197645·8906
⅜	183·3905	2676·3547	51·7335	3407·6406	198921·0214
½	183·7832	2687·8289	51·8443	3422·25	200201·625
⅝	184·1759	2699·3276	51·9551	3436·8906	201487·7129
¾	184·5686	2710·8508	52·0658	3451·5625	202779·2969
⅞	184·9613	2722·3987	52·1766	3466·2656	204076·3886
59 *in.*	185·3540	2733·9710	52·2874	3481·	205379·
⅛	185·7467	2745·5679	52·3982	3495·7656	206687·1426
¼	186·1394	2757·1893	52·5089	3510·5625	208000·8281
⅜	186·5321	2768·8353	52·6197	3525·3906	209320·0683
½	186·9248	2780·5058	52·7305	3540·25	210644·875
⅝	187·3175	2792·2009	52·8413	3555·1406	211975·2598
¾	187·7102	2803·9205	52·9521	3570·0625	213311·2344
⅞	188·1029	2815·6646	53·0628	3585·0156	214642·8105

TABLE I.

Dia. or Root.	Circum.	Area.	Side of = square.	Square.	Cube.
60 *in.*	188·4956	2827·4334	53·1736	3600·	216000·
⅛	188·8883	2839·2266	53·2844	3615·0156	217352·8145
¼	189·2810	2851·0444	53·3952	3630·0625	218711·2656
⅜	189·6737	2862·8868	53·5060	3645·1406	220075·3652
½	190·0664	2874·7536	53·6167	3660·25	221445·125
⅝	190·4591	2886·6450	53·7275	3675·3906	222820·5566
¾	190·8518	2898·5610	53·8383	3690·5625	224201·6719
⅞	191·2445	2910·5015	53·9491	3705·7656	225588·4824
61 *in.*	191·6372	2922·4666	54·0598	3721·	226981·
⅛	192·0299	2934·4562	54·1706	3736·2656	228379·2363
¼	192·4226	2946·4703	54·2814	3751·5625	229783·2031
⅜	192·8152	2958·5090	54·3922	3766·8906	231192·9121
½	193·2079	2970·5722	54·5030	3782·25	232608·375
⅝	193·6006	2982·6600	54·6137	3797·6406	234029·6035
¾	193·9933	2994·7723	54·7245	3813·0625	235456·6094
⅞	194·3860	3006·9091	54·8353	3828·5156	236889·4043
62 *in.*	194·7787	3019·0705	54·9461	3844·	238328·
⅛	195·1714	3031·2565	55·0568	3859·5156	239772·4082
¼	195·5641	3043·4670	55·1676	3875·0625	241222·6406
⅜	195·9568	3055·7020	55·2784	3890·6406	242678·7089
½	196·3495	3067·9616	55·3892	3906·25	244140·625
⅝	196·7422	3080·2457	55·5000	3921·8906	245608·4004
¾	197·1349	3092·5544	55·6107	3937·5625	247082·0469
⅞	197·5276	3104·8876	55·7215	3953·2656	248561·5761
63 *in.*	197·9203	3117·2453	55·8323	3969·	250047·
⅛	198·3130	3129·6276	55·9431	3984·7656	251538·3300
¼	198·7057	3142·0344	56·0539	4000·5625	253035·5781
⅜	199·0984	3154·4658	56·1646	4016·3906	254538·7558
½	199·4911	3166·9217	56·2754	4032·25	256047·875
⅝	199·8838	3179·4022	56·3862	4048·1406	257562·9472
¾	200·2765	3191·9072	56·4970	4064·0625	259083·9844
⅞	200·6692	3204·4368	56·6077	4080·0156	260610·9980
64 *in.*	201·0619	3216·9909	56·7185	4096·	262144·
⅛	201·4546	3229·5695	56·8293	4112·0156	263683·0019
¼	201·8473	3242·1727	56·9401	4128·0625	265228·0156
⅜	202·2400	3254·8004	57·0509	4144·1406	266779·0527
½	202·6327	3267·4527	57·1616	4160·25	268336·125
⅝	203·0254	3280·1295	57·2724	4176·3906	269899·2441
¾	203·4181	3292·8309	57·3832	4192·5625	271468·4219
⅞	203·8108	3305·5568	57·4940	4208·7656	273043·6699
65 *in.*	204·2035	3318·3072	57·6048	4225·	274625·
⅛	204·5962	3331·0822	57·7155	4241·2656	276212·4238
¼	204·9889	3343·8818	57·8263	4257·5625	277805·9531
⅜	205·3816	3356·7058	57·9371	4273·8906	279405·5996
½	205·7743	3369·5545	58·0479	4290·25	281011·375
⅝	206·1670	3382·4276	58·1586	4306·6406	282623·2910
¾	206·5597	3395·3253	58·2694	4323·0625	284241·3594
⅞	206·9524	3408·2476	58·3802	4339·5156	285865·5918

TABLE I.

Dia. or Root.	Circum.	Area.	Side of = square.	Square.	Cube.
66 *in.*	207·3451	3421·1944	58·4910	4356·	287496·
⅛	207·7378	3434·1657	58·6018	4372·5156	289132·5957
¼	208·1305	3447·1616	58·7125	4389·0625	290775·3906
⅜	208·5232	3460·1821	58·8233	4405·6406	292424·3964
½	208·9159	3473·2270	58·9341	4422·25	294079·625
⅝	209·3086	3486·2965	59·0449	4438·8906	295741·0879
¾	209·7013	3499·3906	59·1556	4455·5625	297408·7969
⅞	210·0940	3512·5092	59·2664	4472·2656	299082·7637
67 *in.*	210·4867	3525·6524	59·3772	4489·	300763·
⅛	210·8794	3538·8200	59·4880	4505·7656	302449·5176
¼	211·2721	3552·0123	59·5988	4522·5625	304142·3281
⅜	211·6648	3565·2291	59·7095	4539·3906	305841·4433
½	212·0575	3578·4704	59·8203	4556·25	307546·875
⅝	212·4502	3591·7362	59·9311	4573·1406	309258·6348
¾	212·8429	3605·0267	60·0419	4590·0625	310976·7344
⅞	213·2356	3618·3416	60·1527	4607·0156	312701·1855
68 *in.*	213·6283	3631·6811	60·2634	4624·	314432·
⅛	214·0210	3645·0451	60·3742	4641·0156	316169·1894
¼	214·4137	3658·4337	60·4850	4658·0625	317912·7656
⅜	214·8064	3671·8469	60·5958	4675·1406	319662·7402
½	215·1991	3685·2845	60·7065	4692·25	321419·125
⅝	215·5918	3698·7467	60·8173	4709·3906	323181·9316
¾	215·9845	3712·2335	60·9281	4726·5625	324951·1719
⅞	216·3772	3725·7448	61·0389	4743·7656	326726·8574
69 *in.*	216·7699	3739·2807	61·1497	4761·	328509·
⅛	217·1626	3752·8410	61·2604	4778·2656	330297·6113
¼	217·5553	3766·4260	61·3712	4795·5625	332092·7031
⅜	217·9480	3780·0355	61·4820	4812·8906	333894·2871
½	218·3407	3793·6695	61·5928	4830·25	335702·375
⅝	218·7334	3807·3280	61·7035	4847·6406	337516·9785
¾	219·1261	3821·0112	61·8143	4865·0625	339338·1094
⅞	219·5188	3834·7188	61·9251	4882·5156	341165·7793
70 *in.*	219·9115	3848·4510	62·0359	4900·	343000·
⅛	220·3042	3862·2077	62·1467	4917·5156	344840·7832
¼	220·6969	3875·9890	62·2574	4935·0625	346688·1406
⅜	221·0896	3889·7949	62·3682	4952·6406	348542·0839
½	221·4823	3903·6252	62·4790	4970·25	350402·625
⅝	221·8750	3917·4801	62·5898	4987·8906	352269·7754
¾	222·2677	3931·3596	62·7006	5005·5625	354143·5469
⅞	222·6604	3945·2636	62·8113	5023·2656	356023·9511
71 *in.*	223·0531	3959·1921	62·9221	5041·	357911·
⅛	223·4458	3973·1452	63·0329	5058·7656	359804·7051
¼	223·8385	3987·1229	63·1437	5076·5625	361705·0781
⅜	224·2312	4001·1250	63·2544	5094·3906	363612·1308
½	224·6239	4015·1518	63·3652	5112·25	365525·875
⅝	225·0166	4029·2030	63·4760	5130·1406	367446·3222
¾	225·4093	4043·2788	63·5868	5148·0625	369373·4844
⅞	225·8020	4057·3792	63·6976	5166·0156	371307·3730

TABLE I.

Dia. or Root.	Circum.	Area.	Side of = square.	Square.	Cube.
72 *in.*	226·1947	4071·5041	63·8083	5184·	373248·
⅛	226·5874	4085·6535	63·9191	5202·0156	375195·3770
¼	226·9801	4099·8275	64·0299	5220·0625	377149·5156
⅜	227·3728	4114·0260	64·1407	5238·1406	379110·4277
½	227·7655	4128·2491	64·2515	5256·25	381078·125
⅝	228·1582	4142·4967	64·3622	5274·3906	383052·6191
¾	228·5509	4156·7689	64·4730	5292·5625	385033·9219
⅞	228·9436	4171·0656	64·5838	5310·7656	387022·0449
73 *in.*	229·3363	4185·3868	64·6946	5329·	389017·
⅛	229·7290	4199·7326	64·8053	5347·2656	391018·7988
¼	230·1217	4214·1029	64·9161	5365·5625	393027·4531
⅜	230·5144	4228·4978	65·0269	5383·8906	395042·9746
½	230·9071	4242·9172	65·1377	5402·25	397065·375
⅝	231·2998	4257·3612	65·2485	5420·6406	399094·6660
¾	231·6925	4271·8297	65·3592	5439·0625	401130·8594
⅞	232·0852	4286·3227	65·4700	5457·5156	403173·9668
74 *in.*	232·4779	4300·8403	65·5808	5476·	405224·
⅛	232·8706	4315·3825	65·6916	5494·5156	407280·9707
¼	233·2633	4329·9492	65·8023	5513·0625	409344·8906
⅜	233·6560	4344·5404	65·9131	5531·6406	411415·7714
½	234·0487	4359·1562	66·0239	5550·25	413493·625
⅝	234·4414	4373·7965	66·1347	5568·8906	415578·4629
¾	234·8341	4388·4613	66·2455	5587·5625	417670·2969
⅞	235·2267	4403·1507	66·3562	5606·2656	419769·1386
75 *in.*	235·6194	4417·8647	66·4670	5625·	421875·
⅛	236·0121	4432·6032	66·5778	5643·7656	423987·8926
¼	236·4048	4447·3662	66·6886	5662·5625	426107·8281
⅜	236·7975	4462·1538	66·7994	5681·3906	428234·8183
½	237·1902	4476·9659	66·9104	5700·25	430368·875
⅝	237·5829	4491·8025	67·0209	5719·1406	432510·0098
¾	237·9756	4506·6637	67·1317	5738·0625	434658·2344
⅞	238·3683	4521·5495	67·2425	5757·0156	436813·5605
76 *in.*	238·7610	4536·4598	67·3532	5776·	438976·
⅛	239·1537	4551·3946	67·4640	5795·0156	441145·5644
¼	239·5464	4566·3540	67·5748	5814·0625	443322·2656
⅜	239·9391	4581·3379	67·6856	5833·1406	445506·1152
½	240·3318	4596·3464	67·7964	5852·25	447697·125
⅝	240·7245	4611·3794	67·9071	5871·3906	449895·3066
¾	241·1172	4626·4370	68·0179	5890·5625	452100·6719
⅞	241·5099	4641·5191	68·1287	5909·7656	454313·2324
77 *in.*	241·9026	4656·6257	68·2395	5929·	456533·
⅛	242·2953	4671·7569	68·3503	5948·2656	458759·9863
¼	242·6880	4686·9126	68·4610	5967·5625	460994·2031
⅜	243·0807	4702·0929	68·5718	5986·8906	463235·6621
½	243·4734	4717·2977	68·6826	6006·25	465484·375
⅝	243·8661	4732·5271	68·7937	6025·6406	467740·3535
¾	244·2588	4747·7810	68·9041	6045·0625	470003·6094
⅞	244·6515	4763·0594	69·0149	6064·5156	472274·1543

TABLE I.

Dia. or Root.	Circum.	Area.	Side of = square.	Square.	Cube.
78 *in.*	245·0442	4778·3624	69·1257	6084·	474552·
⅛	245·4369	4793·6900	69·2365	6103·5156	476837·1582
¼	245·8296	4809·0420	69·3473	6123·0625	479129·6406
⅜	246·2223	4824·4187	69·4580	6142·6406	481429·4589
½	246·6150	4839·8198	69·5688	6162·25	483736·625
⅝	247·0077	4855·2455	69·6796	6181·8906	486051·1504
¾	247·4004	4870·6958	69·7904	6201·5625	488373·0469
⅞	247·7931	4886·1706	69·9011	6221·2656	490702·3261
79 *in.*	248·1858	4901·6699	70·0119	6241·	493039·
⅛	248·5785	4917·1938	70·1227	6260·7656	495383·0801
¼	248·9712	4932·7423	70·2335	6280·5625	497734·5781
⅜	249·3639	4948·3152	70·3443	6300·3906	500093·5058
½	249·7566	4963·9127	70·4550	6320·25	502459·875
⅝	250·1493	4979·5348	70·5658	6340·1406	504833·6972
¾	250·5420	4995·1814	70·6766	6360·0625	507214·9844
⅞	250·9347	5010·8526	70·7874	6380·0156	509603·7480
80 *in.*	251·3274	5026·5482	70·8982	6400·	512000·
⅛	251·7201	5042·2685	71·0089	6420·0156	514403·7519
¼	252·1128	5058·0133	71·1197	6440·0625	516815·0156
⅜	252·5055	5073·7826	71·2305	6460·1406	519233·8027
½	252·8982	5089·5764	71·3413	6480·25	521660·125
⅝	253·2909	5105·3949	71·4520	6500·3906	524093·9941
¾	253·6836	5121·2378	71·5628	6520·5625	526535·4219
⅞	254·0763	5137·1053	71·6736	6540·7656	528984·4199
81 *in.*	254·4690	5152·9974	71·7844	6561·	531441·
⅛	254·8617	5168·9139	71·8952	6581·2656	533905·1738
¼	255·2544	5184·8551	72·0059	6601·5625	536376·9531
⅜	255·6471	5200·8207	72·1167	6621·8906	538856·3496
½	256·0398	5216·8110	72·2275	6642·25	541343·375
⅝	256·4325	5232·8257	72·3383	6662·6406	543838·0410
¾	256·8252	5248·8650	72·4491	6683·0625	546340·3594
⅞	257·2179	5264·9289	72·5598	6703·5156	548850·3418
82 *in.*	257·6106	5281·0173	72·6706	6724·	551368·
⅛	258·0033	5297·1302	72·7814	6744·5156	553893·3457
¼	258·3960	5313·2677	72·8922	6765·0625	556426·3906
⅜	258·7887	5329·4297	73·0029	6785·6406	558967·1464
½	259·1814	5345·6162	73·1137	6806·25	561515·625
⅝	259·5741	5361·8274	73·2245	6826·8906	564071·8379
¾	259·9668	5378·0630	73·3353	6847·5625	566635·7969
⅞	260·3595	5394·3232	73·4461	6868·2656	569207·5137
83 *in.*	260·7522	5410·6079	73·5568	6889·	571787·
⅛	261·1449	5426·9172	73·6676	6909·7656	574374·2676
¼	261·5376	5443·2511	73·7784	6930·5625	576969·3281
⅜	261·9303	5459·6094	73·8892	6951·3906	579572·1933
½	262·3230	5475·9923	73·9999	6972·25	582182·875
⅝	262·7157	5492·3998	74·1107	6993·1406	584801·3848
¾	263·1084	5508·8318	74·2215	7014·0625	587427·7344
⅞	263·5011	5525·2884	74·3323	7035·0156	590061·9355

TABLE I.

Dia. or Root.	Circum.	Area.	Side of = square.	Square.	Cube.
84 *in.*	263 8938	5541·7694	74·4431	7056·	592704
⅛	264·2865	5558·2751	74·5538	7077·0156	595353·9394
¼	264·6792	5574·8053	74·6646	7098·0625	598011·7656
⅜	265·0719	5591·3600	74·7754	7119·1406	600677·4902
½	265·4646	5607·9392	74·8862	7140·25	603351·125
⅝	265·8573	5624·5430	74·9970	7161·3906	606032·6816
¾	266·2500	5641·1714	75·1077	7182·5625	608722·1719
⅞	266·6427	5657·8243	75·2185	7203·7656	611419·6074
85 *in.*	267·0354	5674·5017	75·3293	7225·	614125·
⅛	267·4281	5691·2037	75·4401	7246·2656	616838·3613
¼	267·8208	5707·9302	75·5508	7267·5625	619559·7031
⅜	268·2135	5724·6813	75·6616	7288·8906	622289·0371
½	268·6062	5741·4569	75·7724	7310·25	625026·375
⅝	268·9989	5758·2571	75·8832	7331·6406	627771·7285
¾	269·3916	5775·0818	75·9940	7353·0625	630525·1094
⅞	269·7843	5791·9310	76·1047	7374·5156	633286·5293
86 *in.*	270·1770	5808·8048	76·2155	7396·	636056·
⅛	270·5697	5825·7031	76·3263	7417·5156	638833·5332
¼	270·9624	5842·6260	76·4371	7439·0625	641619·1406
⅜	271·3551	5859·5734	76·5479	7460·6406	644412·8339
½	271·7478	5876·5454	76·6586	7482·25	647214·625
⅝	272·1405	5893·5419	76·7694	7503·8906	650024·5254
¾	272·5332	5910·5630	76·8802	7525·5625	652842·5469
⅞	272·9259	5927·6086	76·9910	7547·2656	655668·7011
87 *in.*	273·3186	5944·6787	77·1017	7569·	658503·
⅛	273·7113	5961·7734	77·2125	7590·7656	661345·4551
¼	274·1040	5978·8926	77·3233	7612·5625	664196·0781
⅜	274·4967	5996·0364	77·4341	7634·3906	667054·8808
½	274·8894	6013·2047	77·5449	7656·25	669921·875
⅝	275·2821	6030·3975	77·6556	7678·1406	672797·0722
¾	275·6748	6047·6149	77·7664	7700·0625	675680·4844
⅞	276·0675	6064·8569	77·8772	7722·0156	678572·1230
88 *in.*	276·4602	6082·1234	77·9880	7744·	681472·
⅛	276·8529	6099·4144	78·0987	7766·0156	684380·1269
¼	277·2456	6116·7300	78·2095	7788·0625	687296·5156
⅜	277·6382	6134·0701	78·3203	7810·1406	690221·1777
½	278·0309	6151·4348	78·4310	7832·25	693154·125
⅝	278·4236	6168·8240	78·5419	7854·3906	696095·3691
¾	278·8163	6186·2377	78·6526	7876·5625	699044·9219
⅞	279·2090	6203·6760	78·7634	7898·7656	702002 7949
89 *in.*	279·6017	6221·1389	78·8742	7921·	704969·
⅛	279·9944	6238·6262	78·9850	7943·2656	707943·5488
¼	280·3871	6256·1382	79·0958	7965·5625	710926·4531
⅜	280·7798	6273·6746	79·2065	7987·8906	713917·7246
½	281·1725	6291·2356	79·3173	8010·25	716917·375
⅝	281·5652	6308·8212	79·4281	8032·6406	719925·4160
¾	281·9579	6326·4313	79·5389	8055·0625	722941·8594
⅞	282·3506	6344·0659	79·6496	8077·5156	725966·7168

TABLE I.

Dia. or Root.	Circum.	Area.	Side of = square.	Square.	Cube.
90 *in.*	282·7433	6361·7251	79·7604	8100·	729000·
⅛	283·1360	6379·4089	79·8712	8122·5156	732041·7207
¼	283·5287	6397·1171	79·9820	8145·0625	735091·8906
⅜	283·9214	6414·8499	80·0928	8167·6406	738150·5214
½	284·3141	6432·6073	80·2035	8190·25	741217·625
⅝	284·7068	6450·3892	80·3143	8212·8906	744293·2129
¾	285·0995	6468·1957	80·4251	8235·5625	747377·2969
⅞	285·4922	6486·0267	80·5359	8258·2656	750469·8886
91 *in.*	285·8849	6503·8822	80·6467	8281·	753571·
⅛	286·2776	6521·7623	80·7574	8303·7656	756680·6426
¼	286·6703	6539·6669	80·8682	8326·5625	759798·8281
⅜	287·0630	6557·5961	80·9790	8349·3906	762925·5683
½	287·4557	6575·5498	81·0898	8372·25	766060·875
⅝	287·8484	6593·5280	81·2005	8395·1406	769204·7598
¾	288·2411	6611·5308	81·3113	8418·0625	772357·2344
⅞	288·6338	6629·5582	81·4221	8441·0156	775518·3105
92 *in.*	289·0265	6647·6101	81·5329	8464·	778688·
⅛	289·4192	6665·6865	81·6437	8487·0156	781866·3144
¼	289·8119	6683·7875	81·7544	8510·0625	785053·2656
⅜	290·2046	6701·9130	81·8652	8533·1406	788248·8652
½	290·5973	6720 0630	81·9760	8556·25	791453·125
⅝	290·9900	6738·2376	82·0868	8579·3906	794666·0566
¾	291·3827	6756·4368	82·1975	8602·5625	797887·6719
⅞	291·7754	6774·6605	82·3083	8625·7656	801117·9824
93 *in.*	292·1681	6792·9087	82·4191	8649·	804357·
⅛	292·5608	6811·1815	82·5299	8672·2656	807604·7363
¼	292·9535	6829·4788	82·6407	8695·5625	810861·2031
⅜	293·3462	6847·8007	82·7514	8718·8906	814126·4121
½	293·7389	6866·1471	82·8622	8742·25	817400·375
⅝	294·1316	6884·5180	82·9730	8765·6406	820683·1035
¾	294·5243	6902·9135	83·0838	8789·0625	823974·6094
⅞	294·9170	6921·3336	83·1946	8812·5156	827274·9043
94 *in.*	295·3097	6939·7782	83·3053	8836·	830584·
⅛	295·7024	6958·2473	83·4161	8859·5156	833901·9082
¼	296·0951	6976·7410	83·5269	8883·0625	837228·6406
⅜	296·4878	6995·2592	83·6377	8906·6406	840564·2089
½	296·8805	7013·8019	83·7484	8930·25	843908·625
⅝	297·2732	7032·3693	83·8592	8953·8906	847261·9004
¾	297·6659	7050·9611	83·9700	8977·5625	850624·0469
⅞	298·0586	7069·5775	84·0808	9001·2656	853995·0761
95 *in.*	298·4513	7088·2184	84·1916	9025·	857375·
⅛	298·8440	7106·8839	84·3023	9048·7656	860763·8301
¼	299·2367	7125·5799	84·4131	9072·5625	864161·5781
⅜	299·6294	7144·2885	84·5239	9096·3906	867568·2558
½	300·0221	7163·0276	84·6347	9120·25	870983·875
⅝	300·4148	7181·7913	84·7454	9144·1406	874408·4472
¾	300·8075	7200·5794	84·8562	9168·0625	877841·9844
⅞	301·2002	7219·3922	84·9670	9192·0156	881284·4980

TABLE I.

Dia. or Root.	Circum.	Area.	Side of = square.	Square.	Cube.
96 *in.*	301·5929	7238·2295	85·0778	9216·	884736·
⅛	301·9856	7257·0913	85·1886	9240·0156	888196·5019
¼	302·3783	7275·9777	85·2993	9264·0625	891666·0156
⅜	302·7710	7294·8886	85·4101	9288·1406	895144·5527
½	303·1637	7313·8240	85·5209	9312·25	898632·125
⅝	303·5564	7332·7840	85·6317	9336·3906	902128·7441
¾	303·9491	7351·7686	85·7425	9360·5625	905634·4219
⅞	304·3418	7370·7777	85·8532	9384·7656	909149·1699
97 *in.*	304·7345	7389·8113	85·9640	9409·	912673·
⅛	305·1272	7408·8695	86·0748	9433·2656	916205·9238
¼	305·5199	7427·9522	86·1856	9457·5625	919747·9531
⅜	305·9126	7447·0595	86·2963	9481·8906	923299·0996
½	306·3053	7466·1913	86·4071	9506·25	926859·375
⅝	306·6980	7485·3476	86·5179	9530·6406	930428·7910
¾	307·0907	7504·5285	86·6287	9555·0625	934007·3594
⅞	307·4834	7523·7340	86·7395	9579·5156	937595·0918
98 *in.*	307·8761	7542·9640	86·8502	9604·	941192·
⅛	308·2688	7562·2185	86·9610	9628·5156	944798·0957
¼	308·6615	7581·4976	87·0718	9653·0625	948413·3906
⅜	309·0542	7600·8012	87·1826	9677·6406	952037·8965
½	309·4469	7620·1293	87·2934	9702·25	955671·625
⅝	309·8396	7639·4820	87·4041	9726·8906	959314·5879
¾	310·2323	7658·8593	87·5149	9751·5625	962966·7969
⅞	310·6250	7678·2611	87·6257	9776·2656	966628·2637
99 *in.*	311·0177	7697·6874	87·7365	9801·	970299·
⅛	311·4104	7717·1383	87·8472	9825·7656	973979·0176
¼	311·8031	7736·6137	87·9580	9850·5625	977668·3281
⅜	312·1958	7756·1137	88·0688	9875·3906	981366·9433
½	312·5885	7775·6382	88·1796	9900·25	985074·875
⅝	312·9812	7795·1872	88·2904	9925·1406	988792·1348
¾	313·3739	7814·7608	88·4011	9950·0625	992518·7344
⅞	313·7666	7834·3590	88·5119	9975·0156	996254·6855
100 *in.*	314·1593	7853·9816	88·6227	10000·	1000000·
¼	314·9447	7893·3006	88·8442	10050·0625	1007518·7656
½	315·7301	7932·7178	89·0658	10100·25	1015075·125
¾	316·5155	7972·2331	89·2874	10150·5625	1022669·1719
101 *in.*	317·3009	8011·8467	89·5089	10201·	1030301·
¼	318·0863	8051·5584	89·7305	10251·5625	1037970·7031
½	318·8717	8091·3682	89·9520	10302·25	1045678·375
¾	319·6571	8131·2763	90·1736	10353·0625	1053424·1093
102 *in.*	320·4425	8171·2825	90·3951	10404·	1061208·
¼	321·2278	8211·3869	90·6167	10455·0625	1069030·1406
½	322·0132	8251·5895	90·8383	10506·25	1076890·625
¾	322·7986	8291·8902	91·0598	10557·5625	1084789·5468

TABLE I.

Dia. or Root.	Circum.	Area.	Side of =square.	Square.	Cube.
103 *in.*	323·5840	8332·2891	91·2814	10609·	1092727·
¼	324·3694	8372·7862	91·5029	10660·5625	1100703·0781
½	325·1548	8413·3815	91·7245	10712·25	1108717·875
¾	325·9402	8454·0749	91·9460	10764·0625	1116771·4843
104 *in.*	326·7256	8494·8665	92·1676	10816·	1124864·
¼	327·5110	8535·7563	92·3892	10868·0625	1132995·5156
½	328·2964	8576·7443	92·6107	10920·25	1141166·125
¾	329·0818	8617·8304	92·8323	10972·5625	1149375·9218
105 *in.*	329·8672	8659·0148	93·0538	11025·	1157625·
¼	330·6526	8700·2972	93·2754	11077·5625	1165913·4531
½	331·4380	8741·6779	93·4969	11130·25	1174241·375
¾	332·2234	8783·1567	93·7185	11183·0625	1182608·8593
106 *in.*	333·0088	8824·7338	93·9401	11236·	1191016·
¼	333·7942	8866·4090	94·1616	11289·0625	1199462·8906
½	334·5796	8908·1823	94·3832	11342·25	1207949·625
¾	335·3650	8950·0539	94·6047	11395·5625	1216476·2968
107 *in.*	336·1504	8992·0236	94·8263	11449·	1225043·
¼	336·9358	9034·0915	95·0478	11502·5625	1233649·8281
½	337·7212	9076·2575	95·2694	11556·25	1242296·875
¾	338·5066	9118·5218	95·4910	11610·0625	1250984·2343
108 *in.*	339·2920	9160·8842	95·7125	11664·	1259712·
¼	340·0774	9203·3448	95·9341	11718·0625	1268480·2656
½	340·8628	9245·9035	96·1556	11772·25	1277289·125
¾	341·6482	9288·5605	96·3772	11826·5625	1286138·6718
109 *in.*	342·4336	9331·3156	96·5987	11881·	1295029·
¼	343·2190	9374·1689	96·8203	11935·5625	1303960·2031
½	344·0044	9417·1203	97·0418	11990·25	1312932·375
¾	344·7898	9460·1700	97·2634	12045·0625	1321945·6093
110 *in.*	345·5752	9503·3178	97·4850	12100·	1331000·

EXAMPLES TO THE PRECEDING TABLE I.*

Ex. 1. The diameter of a circle being $83\frac{7}{8}$ *inches*, required its circumference?

Here, in column 1, *page* 15, we find the diameter $83\frac{7}{8}$ in *inches*, *feet*, *yards*, *chains*, *miles*, &c.; the corresponding circumference will be found in column 2; hence, the diameter being $83\frac{7}{8}$ *inches*, the circumference is 263·5011 *inches* = *Ans.* The same result may be found by Prob. IX., *page* 50; *thus* 3·14159265 × $83\frac{7}{8}$ *in.* = 263·50108352 *inches* = *Ans. as before.*

Ex. 2. What is the area of a square whose side is 35·25 chains = $35\frac{1}{4}$ chains?

Here, in column 1, *page* 7, we find the side $35\frac{1}{4}$ in *inches*, *feet*, *yards*, *chains*, *miles*, &c.; the corresponding square will be found in column 5; hence, the side being $35\frac{1}{4}$ *chains*, the area of the square will be 1242·5625 *square chains* = 124·25625 *acres* = 124 *acres* 1 *rood* 1 *perch* = *Ans.* The same result may also be found by Prob. I. *page* 44; *thus* 35·25 × 35·25 = 1242·5625 *sq. chains* = *Ans. as before.*

Ex. 3. A cellar is to be dug whose length, breadth, and depth are each 10 feet 3 inches (= $10\frac{1}{4}$ inches), how many solid feet does it contain, and what will it cost digging at 1*s.* per solid yard?

Here, in column 1, *page* 3, we find the side $10\frac{1}{4}$ in *inches*, *feet*, *yards*, *chains*, *miles*, &c.; the corresponding cube will be found in column 6; hence, the side being $10\frac{1}{4}$ *feet*, the solid content or cube will be 1076·890625 *cubic feet* = 39·8848 *cubic yards* = 1*st Ans.*, and the cost of digging will be 39·8848 *shillings* = 1*l.* 19*s.* $10\frac{1}{2}$*d.* = 2*nd Ans.* Similarly, by Prob. I. *page* 44, the area of any side or base of the cube will be 10·25 × 10·25 = 105·0625 *sq. feet*; and by Prob. I. *page* 59, the solid content may be found = 1076·890625 *cubic feet*, and therefore the rest as before.

Ex. 4. The length of a line with which a gardener formed a circular fish-pond was exactly $27\frac{3}{4}$ *yards*, what quantity of ground did the fish-pond take up.

Here, in column 1, *page* 11, we find the diameter $55\frac{1}{2}$ (= $27\frac{3}{4}$ × 2) in *inches*, *feet*, *yards*, *chains*, *miles*, &c.; the corresponding area of the circle will be found in column 3; hence, the diameter being $55\frac{1}{2}$ *yards*, the area will be 2419·2227 *square yards*, or *half an acre nearly* = *Ans.* The same result may be found as in Ex. 1, *page* 55, using ·78539816 in place of ·7854; thus $55\frac{1}{2}$ squared × ·78539816 = $55{\cdot}5^2$ × ·78539816 = 2419·22268234 *square yards* = *Ans. as before.*

Ex. 5. If the diameter of a circle be 91 *miles* 5 *furlongs* (= $91\frac{5}{8}$ *miles*), what is the side of a square equal in area to that circle?

Here, in column 1, *page* 17, we find the diameter $91\frac{5}{8}$ in *inches*, *feet*, *yards*, *chains*, *miles*, &c.; the corresponding side of the equal square will be found in column 4; hence, the diameter being $91\frac{5}{8}$ *miles*, the sides of the equal square will be 81·2005 *miles* = 81 *miles* 1 *furlong* 24 *poles* 2 *feet* 2 *inches* = *Ans.* The same result may be found as in Ex. 1, *page* 54, using ·8862269 in place of ·8862; thus $91\frac{5}{8}$ × ·8862269 = 81·2005397125 *square miles* = *Ans. as before.*

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* The references to the Problems made use of in the arithmetical computations for testing the tables, are taken from Templeton's "Millwright and Engineer's Pocket Companion." *Edition* 1852.

TABLE II.

CONTAINING THE

CIRCUMFERENCES AND AREAS OF CIRCLES;

ALSO,

THE SIDE OF A SQUARE OF EQUAL AREA,

AND THE

CONTENTS OF CYLINDERS IN CUBIC YARDS AND IMPERIAL GALLONS,
AT 1 FOOT IN DEPTH, FROM 1 TO 50 FEET DIAMETER,
ADVANCING BY AN INCH.

TABLE II.

Dia. in *feet* and *inches*.	Circum. in *feet* and *inches*.	Area in *square feet*.	Side of = square in *ft.* and *in.*	Cubic yards at one *foot* in depth.	Gallons at one *foot* in depth.
ft. *in.*	*ft.* *in.*		*ft.* *in.*		
0 . 1	0 . $3\frac{1}{8}$	·0055	0 . $0\frac{7}{8}$	·0002	·0340
2	0 . $6\frac{1}{4}$	·0218	0 . $1\frac{3}{4}$	·0008	·1360
3	0 . $9\frac{3}{8}$	·0491	0 . $2\frac{5}{8}$	·0018	·3059
4	1 . $0\frac{1}{2}$	·0873	0 . $3\frac{1}{2}$	·0032	·5439
5	1 . $3\frac{3}{4}$	·1364	0 . $4\frac{3}{8}$	·0051	·8498
6	1 . $6\frac{7}{8}$	·1963	0 . $5\frac{1}{4}$	·0073	1·2237
7	1 . 10	·2673	0 . $6\frac{1}{8}$	·0099	1·6656
8	2 . $1\frac{1}{8}$	·3491	0 . 7	·0129	2·1754
9	2 . $4\frac{1}{4}$	·4418	0 . $7\frac{7}{8}$	·0164	2·7533
10	2 . $7\frac{3}{8}$	·5454	0 . $8\frac{3}{4}$	·0202	3·3991
11	2 . $10\frac{1}{2}$	·6600	0 . $9\frac{3}{4}$	·0244	4·1129
1 *ft.*	3 . $1\frac{3}{4}$	·7854	0 . $10\frac{5}{8}$	·0291	4·8947
1	3 . $4\frac{7}{8}$	·9218	0 . $11\frac{1}{2}$	·0341	5·7445
2	3 . 8	1·0690	1 . $0\frac{3}{8}$	·0396	6·6622
3	3 . $11\frac{1}{8}$	1·2272	1 . $1\frac{1}{4}$	·0455	7·6479
4	4 . $2\frac{1}{4}$	1·3963	1 . $2\frac{1}{8}$	·0517	8·7017
5	4 . $5\frac{3}{8}$	1·5763	1 . $3\frac{1}{8}$	·0584	9·8234
6	4 . $8\frac{1}{2}$	1·7671	1 . 4	·0654	11·0130
7	4 . $11\frac{3}{4}$	1·9689	1 . $4\frac{7}{8}$	·0729	12·2707
8	5 . $2\frac{7}{8}$	2·1817	1 . $5\frac{3}{4}$	·0808	13·5963
9	5 . 6	2·4053	1 . $6\frac{5}{8}$	·0891	14·9900
10	5 . $9\frac{1}{8}$	2·6398	1 . $7\frac{1}{2}$	·0978	16·4516
11	6 . $0\frac{1}{4}$	2·8852	1 . $8\frac{3}{8}$	·1069	17·9812
2 *ft.*	6 . $3\frac{3}{8}$	3·1416	1 . $9\frac{1}{4}$	·1164	19·5787
1	6 . $6\frac{1}{2}$	3·4088	1 . $10\frac{1}{8}$	·1263	21·2423
2	6 . $9\frac{5}{8}$	3·6870	1 . 11	·1366	22·9778
3	7 . $0\frac{7}{8}$	3·9761	1 . $11\frac{7}{8}$	·1473	24·7793
4	7 . 4	4·2761	2 . $0\frac{7}{8}$	·1584	26·6488
5	7 . $7\frac{1}{8}$	4·5869	2 . $1\frac{3}{4}$	·1699	28·5863
6	7 . $10\frac{1}{4}$	4·9087	2 . $2\frac{5}{8}$	·1818	30·5918
7	8 . $1\frac{3}{8}$	5·2414	2 . $3\frac{1}{2}$	·1941	32·6652
8	8 . $4\frac{1}{2}$	5·5851	2 . $4\frac{3}{8}$	·2069	34·8066
9	8 . $7\frac{5}{8}$	5·9396	2 . $5\frac{1}{4}$	·2200	37·0161
10	8 . $10\frac{7}{8}$	6·3050	2 . $6\frac{1}{8}$	·2335	39·2934
11	9 . 2	6·6813	2 . 7	·2475	41·6388
3 *ft.*	9 . $5\frac{1}{8}$	7·0686	2 . $7\frac{7}{8}$	·2618	44·0522
1	9 . $8\frac{1}{4}$	7·4667	2 . $8\frac{3}{4}$	·2765	46·5335
2	9 . $11\frac{3}{8}$	7·8758	2 . $9\frac{5}{8}$	·2917	49·0828
3	10 . $2\frac{1}{2}$	8·2958	2 . $10\frac{5}{8}$	·3073	51·7001
4	10 . $5\frac{5}{8}$	8·7266	2 . $11\frac{1}{2}$	·3232	54·3854
5	10 . $8\frac{3}{4}$	9·1684	3 . $0\frac{3}{8}$	·3396	57·1386
6	11 . 0	9·6211	3 . $1\frac{1}{4}$	·3563	59·9599
7	11 . $3\frac{1}{8}$	10·0847	3 . $2\frac{1}{8}$	·3735	62·8491
8	11 . $6\frac{1}{4}$	10·5592	3 . $3\frac{1}{8}$	·3911	65·8063
9	11 . $9\frac{3}{8}$	11·0447	3 . $3\frac{7}{8}$	·4091	68·8315
10	12 . $0\frac{1}{2}$	11·5410	3 . $4\frac{3}{4}$	·4274	71·9247
11	12 . $3\frac{5}{8}$	12·0482	3 . $5\frac{5}{8}$	·4462	75·0858

TABLE II.

Dia. in *feet* and *inches.*	Circum. in *feet* and *inches.*	Area in *square feet.*	Side of = square in *ft.* and *in.*	Cubic yards at one *foot* in depth.	Gallons at one *foot* in depth.
ft. *in.*	*ft.* *in.*		*ft.* *in.*		
4 . 0	12 . 6¾	12·5664	3 . 6½	·4654	78·3150
1	12 . 10	13·0954	3 . 7⅝	·4850	81·6121
2	13 . 1⅛	13·6354	3 . 8¼	·5050	84·9772
3	13 . 4¼	14·1863	3 . 9¼	·5254	88·4102
4	13 . 7⅜	14·7480	3 . 10⅛	·5462	91·9113
5	13 . 10½	15·3207	3 . 11	·5674	95·4803
6	14 . 1⅝	15·9043	3 . 11⅞	·5890	99·1174
7	14 . 4¾	16·4988	4 . 0¼	·6111	102·8224
8	14 . 7⅞	17·1042	4 . 1⅝	·6335	106·5954
9	14 . 11⅛	17·7205	4 . 2½	·6563	110·4363
10	15 . 2¼	18·3478	4 . 3⅞	·6795	114·3453
11	15 . 5⅜	18·9859	4 . 4¼	·7032	118·3222
5 *ft.*	15 . 8½	19·6350	4 . 5⅛	·7272	122·3671
1	15 . 11⅝	20·2949	4 . 6	·7517	126·4800
2	16 . 2¾	20·9658	4 . 7	·7765	130·6609
3	16 . 5⅞	21·6475	4 . 7⅞	·8018	134·9097
4	16 . 9	22·3402	4 . 8¾	·8274	139·2266
5	17 . 0¼	23·0438	4 . 9⅝	·8535	143·6114
6	17 . 3⅜	23·7583	4 . 10½	·8799	148·0642
7	17 . 6½	24·4837	4 . 11⅜	·9068	152·5850
8	17 . 9⅝	25·2200	5 . 0¼	·9341	157·1738
9	18 . 0¾	25·9672	5 . 1⅛	·9617	161·8305
10	18 . 3⅞	26·7254	5 . 2	·9898	166·5552
11	18 . 7	27·4944	5 . 2⅞	1·0183	171·3480
6 *ft.*	18 . 10¼	28·2743	5 . 3¾	1·0472	176·2086
1	19 . 1⅜	29·0652	5 . 4¼	1·0765	181·1373
2	19 . 4½	29·8669	5 . 5⅛	1·1062	186·1340
3	19 . 7⅝	30·6796	5 . 6½	1·1363	191·1986
4	19 . 10¾	31·5032	5 . 7⅜	1·1668	196·3312
5	20 . 1⅞	32·3377	5 . 8¼	1·1977	201·5318
6	20 . 5	33·1831	5 . 9⅛	1·2290	206·8004
7	20 . 8¼	34·0394	5 . 10	1·2607	212·1370
8	20 . 11⅜	34·9066	5 . 10⅞	1·2928	217·5415
9	21 . 2½	35·7847	5 . 11¾	1·3254	223·0141
10	21 . 5⅝	36·6737	6 . 0⅝	1·3583	228·5546
11	21 . 8¾	37·5737	6 . 1½	1·3916	234·1631
7 *ft.*	21 . 11⅞	38·4846	6 . 2⅜	1·4254	239·8395
1	22 . 3	39·4063	6 . 3⅜	1·4595	245·5840
2	22 . 6¼	40·3389	6 . 4¼	1·4940	251·3964
3	22 . 9⅜	41·2825	6 . 5⅛	1·5290	257·2769
4	23 . 0½	42·2370	6 . 6	1·5643	263·2253
5	23 . 3⅝	43·2024	6 . 6⅞	1·6001	269·2416
6	23 . 6¾	44·1786	6 . 7¾	1·6362	275·3260
7	23 . 9⅞	45·1658	6 . 8⅝	1·6728	281·4784
8	24 . 1	46·1640	6 . 9½	1·7098	287·6987
9	24 . 4⅛	47·1730	6 . 10⅜	1·7471	293·9870
10	24 . 7¼	48·1929	6 . 11¼	1·7849	300·3433
11	24 . 10½	49·2237	7 . 0¼	1·8231	306·7676

TABLE II.

Dia. in *feet* and *inches.*	Circum. in *feet* and *inches.*	Area in *square feet.*	Side of = square in *ft.* and *in.*	Cubic yards at one *foot* in depth.	Gallons at one *foot* in depth.
ft. *in.*	*ft.* *in.*		*ft.* *in.*		
8 . 0	25 . 1⅝	50·2655	7 . 1⅛	1·8617	313·2598
1	25 . 4¾	51·3181	7 . 2	1·9007	319·8201
2	25 . 7⅞	52·3817	7 . 2⅞	1·9401	326·4483
3	25 . 11	53·4562	7 . 3¾	1·9799	333·1445
4	26 . 2⅛	54·5415	7 . 4⅝	2·0201	339·9087
5	26 . 5¼	55·6378	7 . 5½	2·0607	346·7408
6	26 . 8½	56·7450	7 . 6⅜	2·1017	353·6410
7	26 . 11⅝	57·8631	7 . 7¼	2·1431	360·6091
8	27 . 2¾	58·9921	7 . 8⅛	2·1849	367·6452
9	27 . 5⅞	60·1320	7 . 9	2·2271	374·7493
10	27 . 9	61·2829	7 . 10	2·2697	381·9214
11	28 . 0⅛	62·4446	7 . 10⅞	2·3128	389·1614
9 *ft.*	28 . 3¼	63·6173	7 . 11¾	2·3562	396·4695
1	28 . 6⅜	64·8008	8 . 0⅝	2·4000	403·8455
2	28 . 9⅝	65·9953	8 . 1½	2·4443	411·2895
3	29 . 0¾	67·2006	8 . 2⅜	2·4889	418·8015
4	29 . 3⅞	68·4169	8 . 3¼	2·5340	426·3814
5	29 . 7	69·6441	8 . 4⅛	2·5794	434·0294
6	29 . 10⅛	70·8822	8 . 5	2·6253	441·7453
7	30 . 1¼	72·1312	8 . 5⅞	2·6715	449·5292
8	30 . 4⅜	73·3911	8 . 6¾	2·7182	457·3811
9	30 . 7⅝	74·6619	8 . 7¾	2·7653	465·3010
10	30 . 10¾	75·9436	8 . 8⅝	2·8127	473·2888
11	31 . 1⅞	77·2363	8 . 9½	2·8606	481·3446
10 *ft.*	31 . 5	78·5398	8 . 10⅜	2·9089	489·4685
1	31 . 8⅛	79·8543	8 . 11¼	2·9576	497·6603
2	31 . 11¼	81·1796	9 . 0⅛	3·0067	505·9200
3	32 . 2⅜	82·5159	9 . 1	3·0561	514·2478
4	32 . 5½	83·8631	9 . 1⅞	3·1060	522·6435
5	32 . 8¾	85·2212	9 . 2¾	3·1563	531·1073
6	32 . 11⅞	86·5901	9 . 3⅝	3·2070	539·6390
7	33 . 3	87·9700	9 . 4½	3·2581	548·2387
8	33 . 6⅛	89·3609	9 . 5⅜	3·3097	556·9063
9	33 . 9¼	90·7626	9 . 6⅜	3·3616	565·6420
10	34 . 0⅜	92·1752	9 . 7¼	3·4139	574·4456
11	34 . 3½	93·5987	9 . 8⅛	3·4666	583·3172
11 *ft.*	34 . 6¾	95·0332	9 . 9	3·5197	592·2568
1	34 . 9⅞	96·4785	9 . 9⅞	3·5733	601·2644
2	35 . 1	97·9348	9 . 10¾	3·6272	610·3400
3	35 . 4⅛	99·4020	9 . 11⅝	3·6816	619·4835
4	35 . 7¼	100 8800	10 . 0½	3·7363	628·6951
5	35 . 10⅜	102·3690	10 . 1⅜	3·7914	637·9746
6	36 . 1½	103·8689	10 . 2¼	3·8470	647·3220
7	36 . 4⅝	105 3797	10 . 3⅛	3·9030	656·7375
8	36 . 7⅞	106·9014	10 . 4⅛	3·9593	666·2210
9	36 . 11	108·4340	10 . 5	4·0161	675·7724
10	37 . 2⅛	109·9776	10 . 5⅞	4·0732	685·3918
11	37 . 5¼	111·5320	10 . 6¾	4·1308	695·0792

TABLE II.

Dia. in *feet* and *inches.*	Circum. in *feet* and *inches.*	Area in *square feet.*	Side of = square in *ft.* and *in.*	Cubic yards at one *foot* in depth.	Gallons at one *foot* in depth.
ft. *in.*	*ft.* *in.*		*ft.* *in.*		
12 . 0	37 . 8⅜	113·0973	10 . 7⅝	4·1888	704·8346
1	37 . 11½	114·6736	10 . 8½	4·2472	714·6579
2	38 . 2⅝	116·2607	10 . 9⅝	4·3060	724·5493
3	38 . 5⅞	117·8588	10 . 10¼	4·3651	734·5086
4	38 . 9	119·4678	10 . 11⅛	4·4247	744·5359
5	39 . 0⅛	121·0877	11 . 0	4·4847	754·6312
6	39 . 3¼	122·7185	11 . 0⅞	4·5451	764·7945
7	39 . 6⅜	124·3602	11 . 1⅞	4·6059	775·0257
8	39 . 9½	126·0128	11 . 2¾	4·6671	785·3250
9	40 . 0⅝	127·6763	11 . 3⅝	4·7288	795·6922
10	40 . 3¾	129·3507	11 . 4½	4·7908	806·1274
11	40 . 7	131·0360	11 . 5⅜	4·8532	816·6305
13 *ft.*	40 . 10⅛	132·7323	11 . 6¼	4·9160	827·2017
1	41 . 1¼	134·4394	11 . 7⅛	4·9792	837·8408
2	41 . 4⅜	136·1575	11 . 8	5·0429	848·5480
3	41 . 7½	137·8865	11 . 8⅞	5·1069	859·3231
4	41 . 10⅝	139·6263	11 . 9¾	5·1713	870·1662
5	42 . 1¾	141·3771	11 . 10⅝	5·2362	881·0772
6	42 . 5	143·1388	11 . 11⅝	5·3014	892·0563
7	42 . 8⅛	144·9114	12 . 0½	5·3671	903·1033
8	42 . 11¼	146·6949	12 . 1⅜	5·4331	914·2183
9	43 . 2⅜	148·4893	12 . 2¼	5·4996	925·4013
10	43 . 5½	150·2947	12 . 3⅛	5·5665	936·6523
11	43 . 8⅝	152·1109	12 . 4	5·6337	947·9713
14 *ft.*	43 . 11¾	153·9380	12 . 4⅞	5·7014	959·3582
1	44 . 2⅞	155·7761	12 . 5¾	5·7695	970·8131
2	44 . 6⅛	157·6250	12 . 6⅝	5·8380	982·3360
3	44 . 9¼	159·4849	12 . 7½	5·9068	993·9269
4	45 . 0⅜	161·3557	12 . 8⅜	5·9761	1005·5858
5	45 . 3½	163·2374	12 . 9⅜	6·0458	1017·3126
6	45 . 6⅝	165·1300	12 . 10¼	6·1159	1029·1074
7	45 . 9¾	167·0335	12 . 11⅛	6·1864	1040·9703
8	46 . 0⅞	168·9479	13 . 0	6·2573	1052·9011
9	46 . 4	170·8732	13 . 0⅞	6·3286	1064·8998
10	46 . 7⅛	172·8094	13 . 1¾	6·4003	1076·9666
11	46 . 10⅜	174·7565	13 . 2⅝	6·4725	1089·1013
15 *ft.*	47 . 1½	176·7146	13 . 3½	6·5450	1101·3040
1	47 . 4⅝	178·6835	13 . 4⅜	6·6179	1113·5747
2	47 . 7¾	180·6634	13 . 5¼	6·6912	1125·9134
3	47 . 10⅞	182·6542	13 . 6⅛	6·7650	1138·3201
4	48 . 2	184·6558	13 . 7⅛	6·8391	1150·7947
5	48 . 5¼	186·6684	13 . 8	6·9136	1163·3374
6	48 . 8⅜	188·6919	13 . 8⅞	6·9886	1175·9480
7	48 . 11½	190·7263	13 . 9¾	7·0639	1188·6266
8	49 . 2⅝	192·7716	13 . 10⅝	7·1397	1201·3732
9	49 . 5¾	194·8278	13 . 11½	7·2158	1214·1877
10	49 . 8⅞	196·8950	14 . 0⅜	7·2924	1227·0702
11	50 . 0	198·9730	14 . 1¼	7·3694	1240·0208

TABLE II.

Dia. in *feet* and *inches.*	Circum. in *feet* and *inches.*	Area in *square feet.*	Side of = square in *ft.* and *in.*	Cubic yards at one *foot* in depth.	Gallons at one *foot* in depth.
ft. *in.*	*ft.* *in.*		*ft.* *in.*		
16 . 0	50 . 3⅛	201·0619	14 . 2⅛	7·4467	1253·0393
1	50 . 6⅜	203·1618	14 . 3	7·5245	1266·1258
2	50 . 9½	205·2725	14 . 3⅞	7·6027	1279·2802
3	51 . 0⅝	207·3942	14 . 4⅞	7·6813	1292·5027
4	51 . 3¾	209·5268	14 . 5¼	7·7603	1305·7931
5	51 . 6⅞	211·6703	14 . 6⅝	7·8396	1319·1515
6	51 . 10	213·8246	14 . 7½	7·9194	1332·5779
7	52 . 1⅛	215·9899	14 . 8⅝	7·9996	1346·0723
8	52 . 4⅜	218·1662	14 . 9¼	8·0802	1359 6346
9	52 . 7½	220·3533	14 . 10⅛	8·1612	1373·2650
10	52 . 10⅝	222·5513	14 . 11	8·2426	1386·9633
11	53 . 1¾	224·7602	14 . 11⅞	8·3445	1400·7296
17 *ft.*	53 . 4⅞	226·9801	15 . 0¾	8·4067	1414·5639
1	53 . 8	229·2108	15 . 1⅝	8·4893	1428·4661
2	53 . 11⅛	231·4525	15 . 2⅝	8·5723	1442·4364
3	54 . 2¼	233·7050	15 . 3½	8·6557	1456·4746
4	54 . 5½	235·9685	15 . 4⅜	8·7396	1470·5808
5	54 . 8⅝	238·2429	15 . 5¼	8·8238	1484·7550
6	54 . 11¾	240·5282	15 . 6⅛	8·9085	1498·9972
7	55 . 2⅞	242·8244	15 . 7	8·9935	1513·3073
8	55 . 6	245·1315	15 . 7⅞	9·0789	1527·6855
9	55 . 9⅛	247·4495	15 . 8¾	9·1648	1542·1316
10	56 . 0¼	249·7784	15 . 9⅝	9·2511	1556·6457
11	56 . 3¾	252·1183	15 . 10½	9·3377	1571·2278
18 *ft.*	56 . 6⅝	254·4690	15 . 11⅜	9·4248	1585·8778
1	56 . 9¾	256·8307	16 . 0¼	9·5122	1600·5959
2	57 . 0⅞	259·2032	16 . 1¼	9·6001	1615·3819
3	57 . 4⅛	261·5867	16 . 2⅛	9·6884	1630·2359
4	57 . 7⅛	263·9810	16 . 3	9·7771	1645·1579
5	57 . 10¼	266·3863	16 . 3⅞	9·8662	1660·1479
6	58 . 1⅜	268·8025	16 . 4⅞	9·9556	1675·2058
7	58 . 4⅝	271·2296	16 . 5⅝	10·0455	1690·3318
8	58 . 7¾	273·6676	16 . 6½	10·1358	1705·5257
9	58 . 10⅞	276·1165	16 . 7⅜	10·2265	1720·7876
10	59 . 2	278·5764	16 . 8¼	10·3176	1736·1175
11	59 . 5⅛	281·0471	16 . 9⅛	10·4092	1751·5153
19 *ft.*	59 . 8¼	283·5287	16 . 10	10·5011	1766·9812
1	59 . 11⅜	286·0213	16 . 11	10·5934	1782·5150
2	60 . 2⅝	288·5247	16 . 11⅞	10·6861	1798·1168
3	60 . 5¾	291·0391	17 . 0¾	10·7792	1813·7866
4	60 . 8⅞	293·5644	17 . 1⅝	10·8728	1829·5244
5	61 . 0	296·1106	17 . 2½	10·9667	1845·3301
6	61 . 3⅛	298·6477	17 . 3⅜	11·0610	1861·2038
7	61 . 6¼	301·2057	17 . 4¼	11·1558	1877·1456
8	61 . 9⅜	303·7746	17 . 5⅛	11·2509	1893·1553
9	62 . 0½	306·3544	17 . 6	11·3465	1909·2329
10	62 . 3¾	308·9451	17 . 6⅞	11·4424	1925·3786
11	62 . 6⅞	311·5467	17 . 7½	11·5388	1941·5922

TABLE II.

Dia. in *feet* and *inches.*	Circum. in *feet* and *inches.*	Area in *square feet.*	Side of — square in *ft.* and *in.*	Cubic yards at one *foot* in depth.	Gallons at one *foot* in depth.
ft. *in.*	*ft.* *in.*		*ft.* *in.*		
20 . 0	62 . 10	314·1593	17 . 8¾	11·6355	1957·8739
1	63 . 1⅛	316·7827	17 . 9⅝	11·7327	1974·2235
2	63 . 4¼	319·4171	17 . 10½	11·8303	1990·6411
3	63 . 7⅜	322·0623	17 . 11⅜	11·9282	2007·1266
4	63 . 10½	324·7185	18 . 0¼	12·0266	2023·6802
5	64 . 1¾	327·3856	18 . 1⅛	12·1254	2040·3017
6	64 . 4⅞	330·0636	18 . 2	12·2246	2056·9912
7	64 . 8	332·7525	18 . 2⅞	12·3242	2073·7487
8	64 . 11⅛	335·4523	18 . 3¾	12·4242	2090·5742
9	65 . 2¼	338·1630	18 . 4⅝	12·5246	2107·4677
10	65 . 5⅜	340·8846	18 . 5½	12·6254	2124·4291
11	65 . 8½	343·6172	18 . 6½	12·7266	2141·4585
21 *ft.*	65 . 11⅝	346·3606	18 . 7⅜	12·8282	2158·5559
1	66 . 2⅞	349·1149	18 . 8¼	12·9302	2175·7213
2	66 . 6	351·8802	18 . 9⅛	13·0326	2192·9547
3	66 . 9⅛	354·6564	18 . 10	13·1354	2210·2560
4	67 . 0¼	357·4434	18 . 10⅞	13·2386	2227·6254
5	67 . 3⅜	360·2414	18 . 11¾	13·3423	2245·0627
6	67 . 6½	363·0503	19 . 0⅝	13·4463	2262·5680
7	67 . 9⅝	365·8701	19 . 1½	13·5507	2280·1413
8	68 . 0⅞	368·7008	19 . 2⅜	13·6556	2297·7825
9	68 . 4	371·5424	19 . 3¼	13·7608	2315·4918
10	68 . 7⅛	374·3949	19 . 4¼	13·8665	2333·2690
11	68 . 10¼	377·2584	19 . 5⅛	13·9725	2351·1142
22 *ft.*	69 . 1⅜	380·1327	19 . 6	14·0790	2369·0274
1	69 . 4½	383·0180	19 . 6⅞	14·1859	2387·0085
2	69 . 7⅝	385·9141	19 . 7¾	14·2931	2405·0577
3	69 . 10¾	388·8212	19 . 8⅝	14·4008	2423·1748
4	70 . 1⅞	391·7392	19 . 9½	14·5089	2441·3599
5	70 . 5⅛	394·6680	19 . 10⅜	14·6173	2459·6130
6	70 . 8¼	397·6078	19 . 11¼	14·7262	2477·9341
7	70 . 11⅜	400·5585	20 . 0⅛	14·8355	2496·3232
8	71 . 2½	403·5201	20 . 1	14·9452	2514·7802
9	71 . 5⅝	406·4926	20 . 2	15·0553	2533·3052
10	71 . 8¾	409·4761	20 . 2⅞	15·1658	2551·8982
11	72 . 0	412·4704	20 . 3¾	15·2767	2570·5592
23 *ft.*	72 . 3⅛	415·4756	20 . 4⅝	15·3880	2589·2882
1	72 . 6¼	418·4918	20 . 5½	15·4997	2608·0851
2	72 . 9⅜	421·5188	20 . 6⅜	15·6118	2626·9501
3	73 . 0½	424·5568	20 . 7¼	15·7243	2645·8830
4	73 . 3⅝	427·6057	20 . 8⅛	15·8372	2664·8839
5	73 . 6¾	430·6654	20 . 9	15·9506	2683·9527
6	73 . 9⅞	433·7361	20 . 10⅞	16·0643	2703·0896
7	74 . 1⅛	436·8177	20 . 10¾	16·1784	2722·2944
8	74 . 4¼	439·9102	20 . 11¾	16·2930	2741·5673
9	74 . 7⅜	443·0137	21 . 0⅝	16·4079	2760·9081
10	74 . 10½	446·1280	21 . 1½	16·5233	2780·3168
11	75 . 1⅝	449·2532	21 . 2⅜	16·6390	2799·7936

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Dia. in *feet* and *inches.*	Circum. in *feet* and *inches.*	Area in *square feet.*	Side of = square in *ft.* and *in.*	Cubic yards at one *foot* in depth.	Gallons at one *foot* in depth.
ft. *in.*	*ft.* *in.*		*ft.* *in.*		
24 . 0	75 . 4¾	452·3893	21 . 3¼	16·7552	2819·3384
1	75 . 7⅞	455·5364	21 . 4⅛	16·8717	2838·9511
2	75 . 11	458·6943	21 . 5	16·9887	2858·6318
3	76 . 2¼	461·8632	21 . 5⅞	17·1060	2878·3805
4	76 . 5⅜	465·0430	21 . 6¾	17·2238	2898·1972
5	76 . 8½	468·2337	21 . 7⅝	17·3420	2918·0918
6	76 . 11⅝	471·4352	21 . 8½	17·4606	2938·0345
7	77 . 2¾	474·6477	21 . 9⅜	17·5795	2958·0551
8	77 . 5⅞	477·8711	21 . 10⅜	17·6989	2978·1437
9	77 . 9	481·1055	21 . 11¼	17·8187	2998·3003
10	78 . 0¼	484·3507	22 . 0⅛	17·9389	3018·5248
11	78 . 3⅜	487·6068	22 . 1	18·0595	3038·8174
25 *ft.*	78 . 6½	490·8739	22 . 1⅞	18·1805	3059·1779
1	78 . 9⅝	494·1518	22 . 2¾	18·3019	3079·6064
2	79 . 0¾	497·4407	22 . 3⅝	18·4237	3100·1029
3	79 . 3⅞	500·7404	22 . 4½	18·5459	3120·6674
4	79 . 7	504·0511	22 . 5⅜	18·6686	3141·2998
5	79 . 10⅛	507·3727	22 . 6¼	18·7916	3162·0003
6	80 . 1⅜	510·7052	22 . 7⅛	18·9150	3182·7687
7	80 . 4½	514·0486	22 . 8⅛	19·0388	3203·6051
8	80 . 7⅝	517·4029	22 . 9	19·1631	3224·5095
9	80 . 10¾	520·7681	22 . 9⅞	19·2877	3245·4818
10	81 . 1⅞	524·1442	22 . 10¾	19·4127	3266·5222
11	81 . 5	527·5312	22 . 11⅝	19·5382	3287·6305
26 *ft.*	81 . 8⅛	530·9292	23 . 0½	19·6640	3308·8068
1	81 . 11⅜	534·3380	23 . 1⅜	19·7903	3330·0511
2	82 . 2½	537·7578	23 . 2¼	19·9170	3351·3634
3	82 . 5⅝	541·1884	23 . 3⅛	20·0440	3372·7436
4	82 . 8¾	544·6300	23 . 4	20·1715	3394·1919
5	82 . 11⅞	548·0825	23 . 4⅞	20·2994	3415·7081
6	83 . 3	551·5459	23 . 5⅞	20·4276	3437·2923
7	83 . 6⅛	555 0202	23 . 6¾	20·5563	3458·9445
8	83 . 9¼	558·5054	23 . 7⅝	20·6854	3480·6646
9	84 . 0½	562·0015	23 . 8½	20·8149	3502·4528
10	84 . 3⅝	565·5085	23 . 9⅜	20·9448	3524·3089
11	84 . 6¾	569·0264	23 . 10¼	21·0751	3546·2330
27 *ft.*	84 . 9⅞	572·5553	23 . 11⅛	21·2058	3568·2251
1	85 . 1	576·0950	24 . 0	21·3369	3590·2852
2	85 . 4⅛	579·6457	24 . 0⅞	21·4684	3612·4132
3	85 . 7¼	583·2072	24 . 1¾	21·6003	3634·6093
4	85 . 10½	586·7797	24 . 2⅝	21·7326	3656·8733
5	86 . 1⅝	590·3631	24 . 3⅝	21·8653	3679·2053
6	86 . 4¾	593·9574	24 . 4½	21·9984	3701·6053
7	86 . 7⅞	597·5626	24 . 5⅜	22·1319	3724·0732
8	86 . 11	601·1787	24 . 6¼	22·2659	3746·6092
9	87 . 2⅛	604·8057	24 . 7⅛	22·4002	3769·2131
10	87 . 5¼	608·4436	24 . 8	22·5349	3791·8850
11	87 . 8⅜	612·0921	24 . 8⅞	22·6701	3814·6249

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Dia. in *feet* and *inches.*	Circum. in *feet* and *inches.*	Area in *square feet.*	Side of = square in *ft.* and *in.*	Cubic yards at one *foot* in depth.	Gallons at one *foot* in depth.
ft. *in.*	*ft.* *in.*		*ft.* *in.*		
28 . 0	87 . 11 5/8	615·7522	24 . 9 3/4	22·8056	3837·4328
1	88 . 2 3/4	619·4228	24 . 10 5/8	22·9416	3860·3086
2	88 . 5 7/8	623·1044	24 . 11 1/2	23·0779	3883·2525
3	88 . 9	626·7968	25 . 0 3/8	23·2147	3906·2643
4	89 . 0 1/8	630·5002	25 . 1 3/8	23·3519	3929·3441
5	89 . 3 1/4	634·2145	25 . 2 1/4	23·4894	3952·4918
6	89 . 6 3/8	637·9397	25 . 3 1/8	23·6274	3975·7076
7	89 . 9 5/8	641·6758	25 . 4	23·7658	3998·9914
8	90 . 0 3/4	645·4228	25 . 4 7/8	23·9045	4022·3431
9	90 . 3 7/8	649·1807	25 . 5 3/4	24·0437	4045·7628
10	90 . 7	652·9495	25 . 6 5/8	24·1833	4069·2505
11	90 . 10 1/8	656·7292	25 . 7 1/2	24·3233	4092·8061
29 *ft.*	91 . 1 1/4	660·5199	25 . 8 3/8	24·4637	4116·4298
1	91 . 4 3/8	664·3214	25 . 9 1/4	24·6045	4140·1214
2	91 . 7 1/2	668·1339	25 . 10 1/8	24·7457	4163·8810
3	91 . 10 5/8	671·9572	25 . 11 1/8	24·8873	4187·7086
4	92 . 1 7/8	675·7915	26 . 0	25·0293	4211·6042
5	92 . 5	679·6367	26 . 0 7/8	25·1717	4235·5678
6	92 . 8 1/8	683·4928	26 . 1 3/4	25·3145	4259·5993
7	92 . 11 1/4	687·3597	26 . 2 5/8	25·4578	4283·6988
8	93 . 2 3/8	691·2377	26 . 3 1/2	25·6014	4307·8663
9	93 . 5 1/2	695·1265	26 . 4 3/8	25·7454	4332·1018
10	93 . 8 3/4	699·0262	26 . 5 1/4	25·8899	4356·4053
11	93 . 11 7/8	702·9368	26 . 6 1/8	26·0347	4380·7768
30 *ft.*	94 . 3	706·8583	26 . 7	26·1799	4405·2162
1	94 . 6 1/8	710·7908	26 . 7 7/8	26·3256	4429·7236
2	94 . 9 1/4	714·7341	26 . 8 7/8	26·4716	4454·2990
3	95 . 0 3/8	718·6884	26 . 9 3/4	26·6181	4478·9424
4	95 . 3 1/2	722·6536	26 . 10 5/8	26·7649	4503·6537
5	95 . 6 5/8	726·6297	26 . 11 1/2	26·9122	4528·4331
6	95 . 9 7/8	730·6166	27 . 0 3/8	27·0599	4553·2804
7	96 . 1	734·6145	27 . 1 1/4	27·2079	4578·1957
8	96 . 4 1/8	738·6233	27 . 2 1/8	27·3564	4603·1790
9	96 . 7 1/4	742·6431	27 . 3	27·5053	4628·2303
10	96 . 10 3/8	746·6737	27 . 3 7/8	27·6546	4653·3495
11	97 . 1 1/2	750·7152	27 . 4 3/4	27·8043	4678·5367
31 *ft.*	97 . 4 5/8	754·7676	27 . 5 5/8	27·9544	4703·7919
1	97 . 7 7/8	758·8310	27 . 6 5/8	28·1049	4729·1151
2	97 . 11	762·9052	27 . 7 1/2	28·2557	4754·5063
3	98 . 2 1/8	766·9904	27 . 8 3/8	28·4071	4779·9655
4	98 . 5 1/4	771·0865	27 . 9 1/4	28·5588	4805·4926
5	98 . 8 3/8	775·1934	27 . 10 1/8	28·7109	4831·0877
6	98 . 11 1/2	779·3113	27 . 11	28·8634	4856·7508
7	99 . 2 5/8	783·4401	27 . 11 7/8	29·0163	4882·4819
8	99 . 5 3/4	787·5798	28 . 0 3/4	29·1696	4908·2810
9	99 . 9	791·7304	28 . 1 5/8	29·3233	4934·1480
10	100 . 0 1/8	795·8920	28 . 2 1/2	29·4775	4960·0831
11	100 . 3 1/4	800·0644	28 . 3 3/8	29·6320	4986·0861

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ft. *in.*	*ft.* *in.*		*ft.* *in.*		
32 . 0	100 . 6⅜	804·2477	28 . 4¼	29·7870	5012·1571
1	100 . 9½	808·4420	28 . 5¼	29·9423	5038·2961
2	101 . 0⅝	812·6471	28 . 6⅛	30·0980	5064·5030
3	101 . 3¾	816·8632	28 . 7	30·2542	5090·7780
4	101 . 7	821·0901	28 . 7⅞	30·4107	5117·1209
5	101 . 10⅛	825·3280	28 . 8¾	30·5678	5143·5318
6	102 . 1¼	829·5768	28 . 9⅝	30·7251	5170·0107
7	102 . 4⅜	833·8365	28 . 10½	30·8828	5196·5575
8	102 . 7½	838·1071	28 . 11⅜	31·0410	5223·1724
9	102 . 10⅝	842·3886	29 . 0¼	31·1996	5249·8552
10	103 . 1¾	846·6810	29 . 1⅛	31·3586	5276·6060
11	103 . 4⅞	850·9844	29 . 2	31·5179	5303·4248
33 *ft.*	103 . 8⅛	855·2986	29 . 3	31·6777	5330·3116
1	103 . 11¼	859·6237	29 . 3⅞	31·8379	5357·2663
2	104 . 2⅜	863·9598	29 . 4¾	31·9985	5384·2891
3	104 . 5½	868·3068	29 . 5⅝	32·1595	5411·3798
4	104 . 8⅝	872·6646	29 . 6½	32·3209	5438·5385
5	104 . 11¾	877·0334	29 . 7⅜	32·4827	5465·7652
6	105 . 2⅞	881·4131	29 . 8¼	32·6449	5493·0598
7	105 . 6	885·8037	29 . 9⅛	32·8075	5520·4225
8	105 . 9¼	890·2052	29 . 10	32·9706	5547·8531
9	106 . 0⅜	894·6176	29 . 10⅞	33·1340	5575·3517
10	106 . 3½	899·0409	29 . 11¾	33·2978	5602·9183
11	106 . 6⅝	903·4751	30 . 0¾	33·4620	5630·5529
34 *ft.*	106 . 9¾	907·9203	30 . 1⅝	33·6267	5658·2555
1	107 . 0⅞	912·3763	30 . 2½	33·7917	5686·0260
2	107 . 4	916·8433	30 . 3⅜	33·9572	5713·8645
3	107 . 7¼	921·3211	30 . 4¼	34·1230	5741·7710
4	107 . 10⅜	925·8099	30 . 5⅛	34·2893	5769·7455
5	108 . 1½	930·3096	30 . 6	34·4559	5797·7880
6	108 . 4⅝	934·8202	30 . 6⅞	34·6230	5825·8984
7	108 . 7¾	939·3417	30 . 7¾	34·7904	5854·0768
8	108 . 10⅞	943·8741	30 . 8⅝	34·9583	5882·3232
9	109 . 2	948·4174	30 . 9½	35·1266	5910·6376
10	109 . 5⅛	952·9716	30 . 10⅜	35·2952	5939·0200
11	109 . 8⅜	957·5367	30 . 11⅜	35·4643	5967·4704
35 *ft.*	109 . 11½	962·1128	31 . 0¼	35·6338	5995·9887
1	110 . 2⅝	966·6997	31 . 1⅛	35·8037	6024·5750
2	110 . 5¾	971·2975	31 . 2	35·9740	6053·2293
3	110 . 8⅞	975·9063	31 . 3	36·1447	6081·9516
4	111 . 0	980·5260	31 . 3¾	36·3158	6110·7419
5	111 . 3⅛	985·1566	31 . 4⅝	36·4873	6139·6001
6	111 . 6⅜	989·7980	31 . 5½	36·6592	6168·5263
7	111 . 9½	994·4504	31 . 6⅜	36·8315	6197·5205
8	112 . 0⅝	999·1137	31 . 7¼	37·0042	6226·5827
9	112 . 3¾	1003·7879	31 . 8¼	37·1773	6255·7129
10	112 . 6⅞	1008·4731	31 . 9⅛	37·3509	6284·9111
11	112 . 10	1013·1691	31 . 10	37·5248	6314·1772

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ft. *in.*	*ft.* *in.*		*ft.* *in.*		
36 . 0	113 . 1⅛	1017·8760	31 . 10⅞	37·6991	6343·5113
1	113 . 4¼	1022·5939	31 . 11¾	37·8738	6372·9134
2	113 . 7½	1027·3226	32 . 0⅝	38·0490	6402·3835
3	113 . 10⅝	1032·0623	32 . 1½	38·2245	6431·9215
4	114 . 1¾	1036·8128	32 . 2⅜	38·4005	6461·5276
5	114 . 4⅞	1041·5743	32 . 3¼	38·5768	6491·2016
6	114 . 8	1046·3467	32 . 4⅛	38·7536	6520·9436
7	114 . 11⅛	1051·1300	32 . 5	38·9307	6550·7536
8	115 . 2¼	1055·9242	32 . 6	39·1083	6580·6316
9	115 . 5½	1060·7293	32 . 6⅞	39·2863	6610·5775
10	115 . 8⅝	1065·5453	32 . 7¾	39·4646	6640·5915
11	115 . 11¾	1070·3723	32 . 8⅝	39·6434	6670·6734
37 *ft.*	116 . 2⅞	1075·2101	32 . 9½	39·8226	6700·8233
1	116 . 6	1080·0588	32 . 10⅜	40·0222	6731·0412
2	116 . 9⅛	1084·9185	32 . 11¼	40·1822	6761·3270
3	117 . 0¼	1089·7890	33 . 0⅛	40·3626	6791·6809
4	117 . 3⅜	1094·6705	33 . 1	40·5434	6822·1027
5	117 . 6⅝	1099·5629	33 . 1⅞	40·7246	6852·5925
6	117 . 9¾	1104·4662	33 . 2¾	40·9062	6883·1503
7	118 . 0⅞	1109·3804	33 . 3¾	41·0882	6913·7761
8	118 . 4	1114·3055	33 . 4⅝	41·2706	6944·4698
9	118 . 7⅛	1119·2415	33 . 5½	41·4534	6975·2315
10	118 . 10¼	1124·1884	33 . 6⅜	41·6366	7006·0613
11	119 . 1⅜	1129·1462	33 . 7¼	41·8202	7036·9590
38 *ft.*	119 . 4⅝	1134·1149	33 . 8⅛	42·0043	7067·9246
1	119 . 7¾	1139·0946	33 . 9	42·1887	7098·9583
2	119 . 10⅞	1144·0851	33 . 9⅞	42·3735	7130·0599
3	120 . 2	1149·0866	33 . 10¾	42·5588	7161·2296
4	120 . 5⅛	1154·0990	33 . 11⅝	42·7444	7192·4672
5	120 . 8¼	1159·1222	34 . 0½	42·9305	7223·7728
6	120 . 11⅜	1164·1564	34 . 1⅜	43·1169	7255·1463
7	121 . 2½	1169·2015	34 . 2⅜	43·3038	7286·5879
8	121 . 5¾	1174·2575	34 . 3¼	43·4910	7318·0974
9	121 . 8⅞	1179·3244	34 . 4⅛	43·6787	7349·6749
10	122 . 0	1184·4022	34 . 5	43·8668	7381·3204
11	122 . 3⅛	1189·4910	34 . 5⅞	44·0552	7413·0339
39 *ft.*	122 . 6¼	1194·5906	34 . 6¾	44·2441	7444·8154
1	122 . 9⅜	1199·7011	34 . 7⅝	44·4334	7476·6648
2	123 . 0½	1204·8226	34 . 8½	44·6231	7508·5822
3	123 . 3¾	1209·9550	34 . 9⅜	44·8131	7540·5676
4	123 . 6⅞	1215·0982	34 . 10¼	45·0036	7572·6210
5	123 . 10	1220·2524	34 . 11⅛	45·1945	7604·7424
6	124 . 1⅛	1225·4175	35 . 0⅛	45·3858	7636·9317
7	124 . 4¼	1230·5935	35 . 1	45·5775	7669·1891
8	124 . 7⅜	1235·7804	35 . 1⅞	45·7696	7701·5144
9	124 . 10½	1240·9782	35 . 2¾	45·9622	7733·9077
10	125 . 1⅝	1246·1869	35 . 3⅝	46·1551	7766·3689
11	125 . 4⅞	1251·4065	35 . 4½	46·3484	7798·8982

TABLE II.

Dia. in *feet* and *inches.*	Circum. in *feet* and *inches.*	Area in *square feet.*	Side of = square in *ft.* and *in.*	Cubic yards at one *foot* in depth.	Gallons at one *foot* in depth.
ft. *in.*	*ft.* *in.*		*ft.* *in.*		
40 . 0	125 . 8	1256·6370	35 . 5⅜	46·5421	7831·4954
1	125 . 11⅛	1261·8785	35 . 6¼	46·7362	7864·1607
2	126 . 2¼	1267·1309	35 . 7⅛	46·9308	7896·8939
3	126 . 5⅜	1272·3941	35 . 8	47·1257	7929·6951
4	126 . 8½	1277·6683	35 . 8⅞	47·3210	7962·5642
5	126 . 11⅝	1282·9534	35 . 9⅞	47·5168	7995·5014
6	127 . 2⅞	1288·2493	35 . 10¾	47·7129	8028·5065
7	127 . 6	1293·5562	35 . 11⅝	47·9095	8061·5796
8	127 . 9⅛	1298·8740	36 . 0½	48·1064	8094·7207
9	128 . 0¼	1304·2027	36 . 1⅝	48·3038	8127·9298
10	128 . 3⅜	1309·5424	36 . 2¼	48·5016	8161·2068
11	128 . 6½	1314·8929	36 . 3⅛	48·6997	8194·5519
41 *ft.*	128 . 9⅝	1320·2543	36 . 4	48·8983	8227·9649
1	129 . 0¾	1325·6267	36 . 4⅞	49·0973	8261·4459
2	129 . 4	1331·0099	36 . 5¾	49·2967	8294·9949
3	129 . 7⅛	1336·4041	36 . 6⅝	49·4964	8328·6119
4	129 . 10¼	1341·8091	36 . 7⅝	49·6966	8362·2968
5	130 . 1⅜	1347·2251	36 . 8½	49·8972	8396·0497
6	130 . 4½	1352·6520	36 . 9⅜	50·0982	8429·8706
7	130 . 7⅝	1358·0898	36 . 10¼	50·2996	8463·7595
8	130 . 10¾	1363·5385	36 . 11⅛	50·5014	8497·7164
9	131 . 2	1368·9981	37 . 0	50·7036	8531·7413
10	131 . 5⅛	1374·4686	37 . 0⅞	50·9062	8565·8341
11	131 . 8¼	1379·9500	37 . 1¾	51·1093	8599·9949
42 *ft.*	131 . 11⅜	1385·4424	37 . 2⅝	51·3127	8634·2237
1	132 . 2½	1390·9456	37 . 3½	51·5165	8668·5205
2	132 . 5⅝	1396·4598	37 . 4⅜	51·7207	8702·8853
3	132 . 8¾	1401·9848	37 . 5⅜	51·9254	8737·3180
4	132 . 11⅞	1407·5208	37 . 6¼	52·1304	8771·8187
5	133 . 3⅛	1413·0676	37 . 7⅛	52·3358	8806·3875
6	133 . 6¼	1418·6254	37 . 8	52·5417	8841·0242
7	133 . 9⅜	1424·1941	37 . 8⅞	52·7479	8875·7288
8	134 . 0½	1429·7737	37 . 9¾	52·9546	8910·5015
9	134 . 3⅝	1435·3642	37 . 10⅝	53·1616	8945·3421
10	134 . 6¾	1440·9656	37 . 11½	53·3691	8980·2507
11	134 . 9⅞	1446·5780	38 . 0⅜	53·5770	9015·2273
43 *ft.*	135 . 1	1452·2012	38 . 1¼	53·7852	9050·2719
1	135 . 4⅛	1457·8353	38 . 2⅛	53·9939	9085·3845
2	135 . 7⅜	1463·4804	38 . 3⅛	54·2030	9120·5650
3	135 . 10½	1469·1364	38 . 4	54·4125	9155·8136
4	136 . 1⅝	1474·8032	38 . 4⅞	54·6223	9191·1301
5	136 . 4¾	1480·4810	38 . 5¾	54·8326	9226·5146
6	136 . 7⅞	1486·1697	38 . 6⅝	55·0433	9261·9670
7	136 . 11	1491·8693	38 . 7½	55·2544	9297·4875
8	137 . 2¼	1497·5798	38 . 8⅜	55·4659	9333·0759
9	137 . 5⅜	1503·3012	38 . 9¼	55·6778	9368·7323
10	137 . 8½	1509·0335	38 . 10⅛	55·8901	9404·4567
11	137 . 11⅝	1514·7767	38 . 11	56·1028	9440·2491

TABLE II.

Dia. in *feet* and *inches.*	Circum. in *feet* and *inches.*	Area in *square feet.*	Side of = square in *ft.* and *in.*	Cubic yards at one *foot* in depth.	Gallons at one *foot* in depth.
ft. *in.*	*ft.* *in.*		*ft.* *in.*		
44 . 0	138 . $2\frac{3}{4}$	1520·5308	38 . $11\frac{7}{8}$	56·3160	9476·1095
1	138 . $5\frac{7}{8}$	1526·2959	39 . $0\frac{7}{8}$	56·5295	9512 0378
2	138 . 9	1532·0718	39 . $1\frac{3}{4}$	56·7434	9548·0342
3	139 . $0\frac{1}{8}$	1537·8587	39 . $2\frac{5}{8}$	56·9577	9584·0985
4	139 . $3\frac{3}{8}$	1543·6565	39 . $3\frac{1}{2}$	57·1725	9620·2308
5	139 . $6\frac{1}{2}$	1549·4651	39 . $4\frac{3}{8}$	57·3876	9656·4310
6	139 . $9\frac{5}{8}$	1555·2847	39 . $5\frac{1}{4}$	57·6031	9692·6993
7	140 . $0\frac{3}{4}$	1561·1152	39 . $6\frac{1}{8}$	57·8191	9729·0355
8	140 . $3\frac{7}{8}$	1566·9566	39 . 7	58·0354	9765·4397
9	140 . 7	1572·8089	39 . $7\frac{7}{8}$	58·2522	9801·9119
10	140 . $10\frac{1}{8}$	1578·6721	39 . $8\frac{3}{4}$	58·4693	9838·4521
11	141 . $1\frac{3}{8}$	1584·5462	39 . $9\frac{5}{8}$	58·6869	9875·0603
45 *ft.*	141 . $4\frac{1}{2}$	1590·4313	39 . $10\frac{5}{8}$	58·9049	9911·7364
1	141 . $7\frac{5}{8}$	1596·3272	39 . $11\frac{1}{2}$	59·1232	9948·4805
2	141 . $10\frac{3}{4}$	1602·2341	40 . $0\frac{3}{8}$	59·3420	9985·2927
3	142 . $1\frac{7}{8}$	1608·1518	40 . $1\frac{1}{4}$	59·5612	10022·1727
4	142 . 5	1614·0805	40 . $2\frac{1}{8}$	59·7808	10059·1208
5	142 . $8\frac{1}{8}$	1620·0201	40 . 3	60·0007	10096·1369
6	142 . $11\frac{1}{4}$	1625·9705	40 . $3\frac{7}{8}$	60·2211	10133·2209
7	143 . $2\frac{1}{2}$	1631·9319	40 . $4\frac{3}{4}$	60·4419	10170·3729
8	143 . $5\frac{5}{8}$	1637·9042	40 . $5\frac{5}{8}$	60·6631	10207·5929
9	143 . $8\frac{3}{4}$	1643·8874	40 . $6\frac{1}{2}$	60·8847	10244·8809
10	143 . $11\frac{7}{8}$	1649·8816	40 . $7\frac{3}{8}$	61·1067	10282·2369
11	144 . 3	1655·8816	40 . $8\frac{1}{4}$	61·3291	10319·6608
46 *ft.*	144 . $6\frac{1}{8}$	1661·9025	40 . $9\frac{1}{4}$	61·5519	10357·1527
1	144 . $9\frac{1}{4}$	1667·9294	40 . $10\frac{1}{8}$	61·7752	10394·7126
2	145 . $0\frac{1}{2}$	1673·9671	40 . 11	61·9988	10432·3405
3	145 . $3\frac{5}{8}$	1680·0158	40 . $11\frac{7}{8}$	62·2228	10470·0364
4	145 . $6\frac{3}{4}$	1686·0753	41 . $0\frac{3}{4}$	62·4472	10507·8002
5	145 . $9\frac{7}{8}$	1692·1458	41 . $1\frac{5}{8}$	62·6721	10545·6321
6	146 . 1	1698·2272	41 . $2\frac{1}{2}$	62·8973	10583·5319
7	146 . $4\frac{1}{8}$	1704·3195	41 . $3\frac{3}{8}$	63·1229	10621·4997
8	146 . $7\frac{1}{4}$	1710·4227	41 . $4\frac{1}{4}$	63·3490	10659·5355
9	146 . $10\frac{3}{8}$	1716·5368	41 . $5\frac{1}{8}$	63·5754	10697·6392
10	147 . $1\frac{5}{8}$	1722·6618	41 . 6	63·8023	10735·8110
11	147 . $4\frac{3}{4}$	1728·7977	41 . 7	64·0295	10774·0507
47 *ft.*	147 . $7\frac{7}{8}$	1734·9445	41 . $7\frac{7}{8}$	64·2572	10812·3584
1	147 . 11	1741·1023	41 . $8\frac{3}{4}$	64·4853	10850·7341
2	148 . $2\frac{1}{8}$	1747·2709	41 . $9\frac{5}{8}$	64·7137	10889·1778
3	148 . $5\frac{1}{4}$	1753·4505	41 . $10\frac{1}{2}$	64·9426	10927·6894
4	148 . $8\frac{3}{8}$	1759·6410	41 . $11\frac{3}{8}$	65·1719	10966·2690
5	148 . $11\frac{5}{8}$	1765·8423	42 . $0\frac{1}{4}$	65·4016	11004·9166
6	149 . $2\frac{3}{4}$	1772·0546	42 . $1\frac{1}{8}$	65·6317	11043·6322
7	149 . $5\frac{7}{8}$	1778·2778	42 . 2	65·8621	11082·4158
8	149 . 9	1784·5119	42 . $2\frac{7}{8}$	66·0930	11121·2674
9	150 . $0\frac{1}{8}$	1790·7569	42 . $3\frac{3}{4}$	66·3243	11160·1869
10	150 . $3\frac{1}{4}$	1797·0128	42 . $4\frac{3}{4}$	66·5560	11199·1744
11	150 . $6\frac{3}{8}$	1803·2796	42 . $5\frac{5}{8}$	66·7881	11238·2300

TABLE II.

Dia. in *feet* and *inches.*	Circum. in *feet* and *inches.*	Area in *square feet.*	Side of = square in *ft.* and *in.*	Cubic yards at one *foot* in depth.	Gallons at one *foot* in depth.
ft. *in.*	*ft.* *in.*		*ft.* *in.*		
48 . 0	150 . 9 1/2	1809·5574	42 . 6 1/2	67·0206	11277·3534
1	151 . 0 3/4	1815·8460	42 . 7 3/8	67·2536	11316·5449
2	151 . 3 7/8	1822·1456	42 . 8 1/4	67·4869	11355·8044
3	151 . 7	1828·4560	42 . 9 1/8	67·7206	11395·1318
4	151 . 10 1/8	1834·7774	42 . 10	67·9547	11434·5272
5	152 . 1 1/4	1841·1096	42 . 10 7/8	68·1892	11473·9906
6	152 . 4 3/8	1847·4528	42 . 11 3/4	68·4242	11513·5220
7	152 . 7 1/2	1853·8069	43 . 0 5/8	68·6595	11553·1213
8	152 . 10 3/4	1860·1719	43 . 1 1/2	68·8953	11592·7887
9	153 . 1 7/8	1866·5478	43 . 2 3/8	69·1314	11632·5240
10	153 . 5	1872·9346	43 . 3 1/4	69·3679	11672·3273
11	153 . 8 1/8	1879·3324	43 . 4 1/4	69·6049	11712·1986
49 *ft.*	153 . 11 1/4	1885·7410	43 . 5 1/8	69·8423	11752·1378
1	154 . 2 3/8	1892·1605	43 . 6	70·0800	11792·1451
2	154 . 5 1/2	1898·5910	43 . 6 7/8	70·3182	11832·2203
3	154 . 8 5/8	1905·0323	43 . 7 3/4	70·5568	11872·3635
4	154 . 11 7/8	1911·4846	43 . 8 5/8	70·7957	11912·5747
5	155 . 3	1917·9478	43 . 9 1/2	71·0351	11952·8539
6	155 . 6 1/8	1924·4218	43 . 10 3/8	71·2749	11993·2011
7	155 . 9 1/4	1930·9068	43 . 11 1/4	71·5151	12033·6162
8	156 . 0 3/8	1937·4027	44 . 0 1/4	71·7557	12074·0993
9	156 . 3 1/4	1943·9095	44 . 1 1/8	71·9966	12114·6504
10	156 . 6 5/8	1950·4273	44 . 2	72·2380	12155·2695
11	156 . 9 7/8	1956·9559	44 . 2 7/8	72·4798	12195·9566
50 *ft.*	157 . 1	1963·4954	44 . 3 3/4	72·7221	12236·7116

EXAMPLES TO TABLE II.

Ex. 1. Required the circumference of a circle whose diameter is 43 *feet* 5 *inches*?

Here, in *column* 1, *page* 32, will be found 43 *feet* 5 *inches*, the diameter; against which, in *column* 2, will be found 136 *feet* $4\frac{3}{4}$ *inches*, the circumference = *Ans.*

The same result may be found by *Prob.* IX. *p.* 50: *thus*, 3·14159265 × $43\frac{5}{12}$ *ft.* = 136·39748 *feet* = 136 *ft.* $4\frac{3}{4}$ *in.* = *Ans. as before.*

Ex. 2. Required the area of a circle whose diameter is 16 *feet* 9 *inches*?

Here, in *column* 1, *page* 26, will be found 16 *feet* 9 *inches*, against which, in *column* 3, will be found 220·3533 *square feet*, the area = *Ans.*

The same result may be found as in *Ex.* 1, *p.* 55, taking ·78539816 (No. 7) table of useful numbers, *page* 170, in place of ·7854: *thus*, 16 *ft.* 9 *in.* = $16\frac{3}{4}$ *ft.*, then ·78539816 × $16\frac{3}{4}$ *ft.* = 13·15541918 *ft.*, then (13·15541918 × $16\frac{3}{4}$) *sq. ft.* = 220·35327 *sq. ft.* = *Ans. as before.*

Ex. 3. Required the side of a square whose area shall be equal to that of a circle whose diameter is 47 *feet* 11 *inches*?

Here, in *column* 1, *page* 33, will be found 47 *feet* 11 *inches*, against which, in *column* 4, will be found 42 *feet* $5\frac{5}{8}$ *inches*, the side of the equal square = *Ans.*

The same result may be found as in *Ex.* 1, *p.* 54, taking ·886227 (No. 56) table of useful numbers, *page* 174, in place of ·8862, then 47 *ft.* 11 *in.* = $(48 - \frac{1}{12})$ *ft.*, and ·886227 × $(48 - \frac{1}{12})$ *ft.* = 42·538896 *ft.* = 42 *ft.* $5\frac{5}{8}$ *in.* = *Ans. as before.*

Ex. 4. Required the solid content of a cylinder whose diameter is 27 *feet* 5 *inches*, and depth 1 *foot*?

Here, in *column* 1, *page* 28, will be found 27 *feet* 5 *inches*, the diameter; against which, in *column* 5, will be found 21·8653 *cubic yards*, the solid content = *Ans.*

The same result may be found as in *Prob.* I., *Rule* 2, *page* 59: *thus*, ·78539816 × $27\frac{5}{12}$ *ft.* = 21·53299956 *ft.*, and (21·53299956 × $27\frac{5}{12}$ × 1) *cub. ft.* = 590·36307 *cub. ft.* = 21·8653 *cub. yds.* = *Ans. as before.*

Note 1. If the depth of the cylinder differ from 1 foot, the diameter being found in the table, multiply the tabular content by the height of the cylinder in feet, the product will be the required content of the given cylinder in *cubic yards.*

Ex. 5. Required the solid content of a cylinder whose diameter is 17 *feet* 7 *inches*, and depth 135 *inches*?

Here, the depth = 135 *inches* = $11\frac{1}{4}$ *feet*, then, in *column* 1, *page* 26

will be found 17 *feet* 7 *inches*, the diameter; against which, in *column* 5, will be found 8·9935; whence 8·9935 *cubic yards* × $11\frac{1}{4}$ = 101·1769 *cubic yards*, the solid content = *Ans.*

Here, by mensuration, we have ·78539816 × $17\frac{7}{12}$ *ft.* = 13·80991764 *ft.*, and (13·80991764 × $17\frac{7}{12}$) *sq. ft.* = 242·82438517 *sq. ft.* = area of base of the cylinder; next (242·82438517 × $11\frac{1}{4}$) *cub. ft.* = 2731·77433 *cub. ft.* = 101·17683 *cub. yds.* = *Ans. as before.*

Ex. 6. Required the content of a cylinder in *imperial gallons* whose diameter is 33 *feet* 6 *inches*, and depth 1 *foot*?

Here, in *column* 1, *page* 30, will be found 33 *feet* 6 *inches*, against which, in *column* 6, will be found 5493·0598 *imperial gallons* = *Ans.*

The same result may be found by mensuration: *thus*, ·78539816 × $33\frac{1}{2}$ *ft.* = 26·31083836 *ft.*, and (26·31083836 × $33\frac{1}{2}$ × 1) *cub. ft.* = 881·413085 *cub. ft.* = content of the cylinder; then, by No. 89, table of useful numbers, *page* 177, we have ·003606543, the number of imperial gallons in a cubic inch, and this multiplied by 1728 (= 12^3) gives 6·23210606, the number of imperial gallons in a cubic foot; whence, 881·413085 × 6·232106 *imp. gallons* = 5493·0598 *imp. gallons* = *Ans. as before.*

Note 2. If the depth of the cylinder differ from 1 foot, its diameter being found in the table, multiply the tabular content by the depth of the cylinder in *feet*; the product will be of the same denomination as the tabular number, *viz. cubic yards*, or *imperial gallons*, according as the tabular number has been taken out from *column* 5, or from *column* 6, respectively.

Ex. 7. Required the content in *imperial gallons*, of a cylinder whose diameter is 41 *feet* 1 *inch*, and depth 36 *feet* $4\frac{3}{4}$ *inches*?

Here, in *column* 1, *page* 32, will be found 41 *feet* 1 *inch*; against which, in *column* 6, will be found 8261·4459.

Then, 4 *in.* = $\frac{1}{3}$ 8261·4459 *imper. gall.*

36

49568·6754
247843·377
$\frac{1}{2}$ *in.* = $\frac{1}{8}$ 2753·8153
$\frac{1}{4}$ *in.* = $\frac{1}{2}$ 344·2269
172·1134

300682·2080 *imp. gall.* = *Ans.*

Here, also, by mensuration, ·78539816 × $41\frac{1}{12}$ *ft.* = 32·26677441 *ft.*, and (32·26677441 × $41\frac{1}{12}$ × 1) *cub. ft.* = 1325·62665 *cub. feet*, which, multiplied by 6·23210606, gives 8261·4459 *imp. gall.* as in the table, *p.* 32, for 41 *ft.* 1 *in.*; whence, as before, 300682·2080 *imp. gall.* = *Ans.*

TABLE III.

CONTAINING

THE SQUARE AND CUBE ROOTS OF ALL NUMBERS

FROM 1 TO 1000; AND THE

DIFFERENCE EXISTING BETWEEN EACH ROOT,

BY WHICH

THE PROCESS FOR OBTAINING THE ROOTS OF NUMBERS, CONSISTING OF INTEGERS AND DECIMALS, IS CONSIDERABLY FACILITATED.

TABLE III.

CONTAINING THE SQUARE AND CUBE ROOTS OF ALL NUMBERS FROM 1 TO 1000, &c.

No.	Sq. Rt.	Diff.	C. Rts.	Diff.	No.	Sq. Rts.	Diff.	C. Rts.	Diff.
1	1·0000		1·0000		45	6·7082		3·5569	
2	1·4142	·4142	1·2599	·2599	46	6·7823	·0741	3·5830	·0261
3	1·7321	·3179	1·4422	·1823	47	6·8557	·0734	3·6088	·0258
4	2·0000	·2679	1·5874	·1452	48	6·9282	·0725	3·6342	·0254
5	2·2361	·2361	1·7100	·1226	49	7·0000	·0718	3·6593	·0251
6	2·4495	·2134	1·8171	·1071	50	7·0711	·0711	3·6840	·0247
7	2·6458	·1963	1·9129	·0958	51	7·1414	·0703	3·7084	·0244
8	2·8284	·1826	2·0000	·0871	52	7·2111	·0697	3·7325	·0241
9	3·0000	·1716	2·0801	·0801	53	7·2801	·0690	3·7563	·0238
10	3·1623	·1623	2·1544	·0743	54	7·3485	·0684	3·7798	·0235
11	3·3166	·1543	2·2240	·0696	55	7·4162	·0677	3·8030	·0232
12	3·4641	·1475	2·2894	·0654	56	7·4833	·0671	3·8259	·0229
13	3·6056	·1415	2·3513	·0619	57	7·5498	·0665	3·8485	·0226
14	3·7417	·1361	2·4101	·0588	58	7·6158	·0660	3·8709	·0224
15	3·8730	·1313	2·4662	·0561	59	7·6811	·0653	3·8930	·0221
16	4·0000	·1270	2·5198	·0536	60	7·7460	·0649	3·9149	·0219
17	4·1231	·1231	2·5713	·0515	61	7·8102	·0642	3·9365	·0216
18	4·2426	·1195	2·6207	·0494	62	7·8740	·0638	3·9579	·0214
19	4·3589	·1163	2·6684	·0477	63	7·9373	·0633	3·9791	·0212
20	4·4721	·1132	2·7144	·0460	64	8·0000	·0627	4·0000	·0209
21	4·5826	·1105	2·7589	·0445	65	8·0623	·0623	4·0207	·0207
22	4·6904	·1078	2·8020	·0431	66	8·1240	·0617	4·0412	·0205
23	4·7958	·1054	2·8439	·0419	67	8·1854	·0614	4·0615	·0203
24	4·8990	·1032	2·8845	·0406	68	8·2462	·0608	4·0817	·0202
25	5·0000	·1010	2·9240	·0395	69	8·3066	·0604	4·1016	·0199
26	5·0990	·0990	2·9625	·0385	70	8·3666	·0600	4·1213	·0197
27	5·1962	·0972	3·0000	·0375	71	8·4261	·0595	4·1408	·0195
28	5·2915	·0953	3·0366	·0366	72	8·4853	·0592	4·1602	·0194
29	5·3852	·0937	3·0723	·0357	73	8·5440	·0587	4·1793	·0191
30	5·4772	·0920	3·1072	·0349	74	8·6023	·0583	4·1983	·0190
31	5·5678	·0906	3·1414	·0342	75	8·6603	·0580	4·2172	·0189
32	5·6569	·0891	3·1748	·0334	76	8·7178	·0575	4·2358	·0186
33	5·7446	·0877	3·2075	·0327	77	8·7750	·0572	4·2543	·0185
34	5·8310	·0864	3·2396	·0321	78	8·8318	·0568	4·2727	·0184
35	5·9161	·0851	3·2711	·0315	79	8·8882	·0564	4·2908	·0181
36	6·0000	·0839	3·3019	·0308	80	8·9443	·0561	4·3089	·0181
37	6·0828	·0828	3·3322	·0303	81	9·0000	·0557	4·3267	·0178
38	6·1644	·0816	3·3620	·0298	82	9·0554	·0554	4·3445	·0178
39	6·2450	·0806	3·3912	·0292	83	9·1104	·0550	4·3621	·0176
40	6·3246	·0796	3·4200	·0288	84	9·1652	·0548	4·3795	·0174
41	6·4031	·0785	3·4482	·0282	85	9·2195	·0543	4·3968	·0173
42	6·4807	·0776	3·4760	·0278	86	9·2736	·0541	4·4140	·0172
43	6·5574	·0767	3·5034	·0274	87	9·3274	·0538	4·4310	·0170
44	6·6332	·0758	3·5303	·0269	88	9·3808	·0534	4·4480	·0170
45	6·7082	·0750	3·5569	·0266	89	9·4340	·0532	4·4647	·0167

TABLE III.

No.	Sq. Rts.	Diff.	C. Rts.	Diff.	No.	Sq. Rts.	Diff.	C. Rts.	Diff.
89	9·4340		4·4647		137	11·7047		5·1551	
90	9·4868	·0528	4·4814	·0167	138	11·7473	·0426	5·1676	·0125
91	9·5394	·0526	4·4979	·0165	139	11·7898	·0425	5·1801	·0125
92	9·5917	·0523	4·5144	·0165	140	11·8322	·0424	5·1925	·0124
93	9·6437	·0520	4·5307	·0163	141	11·8743	·0421	5·2048	·0123
94	9·6954	·0517	4·5468	·0161	142	11·9164	·0421	5·2171	·0123
95	9·7468	·0514	4·5629	·0161	143	11·9583	·0419	5·2293	·0122
96	9·7980	·0512	4·5789	·0160	144	12·0000	·0417	5·2415	·0122
97	9·8489	·0509	4·5947	·0158	145	12·0416	·0416	5·2536	·0121
98	9·8995	·0506	4·6104	·0157	146	12·0830	·0414	5·2656	·0120
99	9·9499	·0504	4·6261	·0157	147	12·1244	·0414	5·2776	·0120
100	10·0000	·0501	4·6416	·0155	148	12·1655	·0411	5·2896	·0120
101	10·0499	·0499	4·6570	·0154	149	12·2066	·0411	5·3015	·0119
102	10·0995	·0496	4·6723	·0153	150	12·2474	·0408	5·3133	·0118
103	10·1489	·0494	4·6875	·0152	151	12·2882	·0408	5·3251	·0118
104	10·1980	·0491	4·7027	·0152	152	12·3288	·0406	5·3368	·0117
105	10·2470	·0490	4·7177	·0150	153	12·3693	·0405	5·3485	·0117
106	10·2956	·0486	4·7326	·0149	154	12·4097	·0404	5·3601	·0116
107	10·3441	·0485	4·7475	·0149	155	12·4499	·0402	5·3717	·0116
108	10·3923	·0482	4·7622	·0147	156	12·4900	·0401	5·3832	·0115
109	10·4403	·0480	4·7769	·0147	157	12·5300	·0400	5·3947	·0115
110	10·4881	·0478	4·7914	·0145	158	12·5698	·0398	5·4061	·0114
111	10·5357	·0476	4·8059	·0145	159	12·6095	·0397	5·4175	·0114
112	10·5830	·0473	4·8203	·0144	160	12·6491	·0396	5·4288	·0113
113	10·6301	·0471	4·8346	·0143	161	12·6886	·0395	5·4401	·0113
114	10·6771	·0470	4·8488	·0142	162	12·7279	·0393	5·4514	·0113
115	10·7238	·0467	4·8629	·0141	163	12·7671	·0392	5·4626	·0112
116	10·7703	·0465	4·8770	·0141	164	12·8062	·0391	5·4737	·0111
117	10·8167	·0464	4 8910	·0140	165	12·8452	·0390	5·4848	·0111
118	10·8628	·0461	4·9049	·0139	166	12·8841	·0389	5·4959	·0111
119	10·9087	·0459	4·9187	·0138	167	12·9228	·0387	5·5069	·0110
120	10·9545	·0458	4·9324	·0137	168	12·9615	·0387	5·5178	·0109
121	11·0000	·0455	4·9461	·0137	169	13·0000	·0385	5·5288	·0110
122	11·0454	·0454	4·9597	·0136	170	13·0384	·0384	5·5397	·0109
123	11·0905	·0451	4·9732	·0135	171	13·0767	·0383	5·5505	·0108
124	11·1355	·0450	4·9866	·0134	172	13·1149	·0382	5·5613	·0108
125	11·1803	·0448	5·0000	·0134	173	13·1529	·0380	5·5721	·0108
126	11·2250	·0447	5·0133	·0133	174	13·1909	·0380	5·5828	·0107
127	11·2694	·0444	5·0265	·0132	175	13·2288	·0379	5·5934	·0106
128	11·3137	·0443	5·0397	·0132	176	13·2665	·0377	5·6041	·0107
129	11·3578	·0441	5·0528	·0131	177	13·3041	·0376	5·6147	·0106
130	11·4018	·0440	5·0658	·0130	178	13·3417	·0376	5·6252	·0105
131	11·4455	·0437	5·0788	·0130	179	13·3791	·0374	5·6357	·0105
132	11·4891	·0436	5·0916	·0128	180	13·4164	·0373	5·6462	·0105
133	11·5326	·0435	5·1045	·0129	181	13·4536	·0372	5·6567	·0105
134	11·5758	·0432	5·1172	·0127	182	13·4907	·0371	5·6671	·0104
135	11·6190	·0432	5·1299	·0127	183	13·5277	·0370	5·6774	·0103
136	11·6619	·0429	5·1426	·0127	184	13·5647	·0370	5·6877	·0103
137	11·7047	·0428	5·1551	·0125	185	13·6015	·0368	5·6980	·0103

TABLE III.

No.	Sq. Rts.	Diff.	C. Rts.	Diff.	No.	Sq. Rts.	Diff.	C. Rts.	Diff.
185	13·6015		5·6980		233	15·2643		6·1534	
		·0367		·0103			·0328		·0088
186	13·6382		5·7083		234	15·2971		6·1622	
		·0366		·0102			·0326		·0088
187	13·6748		5·7185		235	15·3297		6·1710	
		·0365		·0102			·0326		·0087
188	13·7113		5·7287		236	15·3623		6·1797	
		·0364		·0101			·0325		·0088
189	13·7477		5·7388		237	15·3948		6·1885	
		·0363		·0101			·0324		·0087
190	13·7840		5·7489		238	15·4272		6·1972	
		·0363		·0101			·0324		·0086
191	13·8203		5·7590		239	15·4596		6·2058	
		·0361		·0100			·0323		·0087
192	13·8564		5·7690		240	15·4919		6·2145	
		·0360		·0100			·0323		·0086
193	13·8924		5·7790		241	15·5242		6·2231	
		·0360		·0100			·0321		·0086
194	13·9284		5·7890		242	15·5563		6·2317	
		·0358		·0099			·0322		·0086
195	13·9642		5·7989		243	15·5885		6·2403	
		·0358		·0099			·0320		·0085
196	14·0000		5·8088		244	15·6205		6·2488	
		·0357		·0098			·0320		·0085
197	14·0357		5·8186		245	15·6525		6·2573	
		·0355		·0099			·0319		·0085
198	14·0712		5·8285		246	15·6844		6·2658	
		·0355		·0098			·0318		·0085
199	14·1067		5·8383		247	15·7162		6·2743	
		·0354		·0097			·0318		·0085
200	14·1421		5·8480		248	15·7480		6·2828	
		·0353		·0098			·0317		·0084
201	14·1774		5·8578		249	15·7797		6·2912	
		·0353		·0097			·0317		·0084
202	14·2127		5·8675		250	15·8114		6·2996	
		·0351		·0096			·0316		·0084
203	14·2478		5·8771		251	15·8430		6·3080	
		·0351		·0097			·0315		·0084
204	14·2829		5·8868		252	15·8745		6·3164	
		·0349		·0096			·0315		·0083
205	14·3178		5·8964		253	15·9060		6·3247	
		·0349		·0095			·0314		·0083
206	14·3527		5·9059		254	15·9374		6·3330	
		·0348		·0096			·0313		·0083
207	14·3875		5·9155		255	15·9687		6·3413	
		·0347		·0095			·0313		·0083
208	14·4222		5·9250		256	16·0000		6·3496	
		·0346		·0095			·0312		·0083
209	14·4568		5·9345		257	16·0312		6·3579	
		·0346		·0094			·0312		·0082
210	14·4914		5·9439		258	16·0624		6·3661	
		·0344		·0094			·0311		·0082
211	14·5258		5·9533		259	16·0935		6·3743	
		·0344		·0094			·0310		·0082
212	14·5602		5·9627		260	16·1245		6·3825	
		·0343		·0094			·0310		·0082
213	14·5945		5·9721		261	16·1555		6·3907	
		·0342		·0093			·0309		·0081
214	14·6287		5·9814		262	16·1864		6·3988	
		·0342		·0093			·0309		·0082
215	14·6629		5·9907		263	16·2173		6·4070	
		·0340		·0093			·0308		·0081
216	14·6969		6·0000		264	16·2481		6·4151	
		·0340		·0092			·0307		·0081
217	14·7309		6·0092		265	16·2788		6·4232	
		·0339		·0093			·0307		·0080
218	14·7648		6·0185		266	16·3095		6·4312	
		·0338		·0092			·0306		·0081
219	14·7986		6·0277		267	16·3401		6·4393	
		·0338		·0091			·0306		·0080
220	14·8324		6·0363		268	16·3707		6·4473	
		·0337		·0091			·0305		·0080
221	14·8661		6·0459		269	16·4012		6·4553	
		·0336		·0091			·0305		·0080
222	14·8997		6·0550		270	16·4317		6·4633	
		·0335		·0091			·0304		·0080
223	14·9332		6·0641		271	16·4621		6·4713	
		·0334		·0091			·0303		·0079
224	14·9666		6·0732		272	16·4924		6·4792	
		·0334		·0090			·0303		·0080
225	15·0000		6·0822		273	16·5227		6·4872	
		·0333		·0090			·0302		·0079
226	15·0333		6·0912		274	16·5529		6·4951	
		·0332		·0090			·0302		·0079
227	15·0665		6·1002		275	16·5831		6·5030	
		·0332		·0089			·0301		·0078
228	15·0997		6·1091		276	16·6132		6·5108	
		·0330		·0089			·0301		·0079
229	15·1327		6·1180		277	16·6433		6·5187	
		·0331		·0089			·0300		·0078
230	15·1658		6·1269		278	16·6733		6·5265	
		·0329		·0089			·0300		·0078
231	15·1987		6·1358		279	16·7033		6·5343	
		·0328		·0088			·0299		·0078
232	15·2315		6·1446		280	16·7332		6·5421	
		·0328		·0088			·0299		·0078
233	15·2643		6·1534		281	16·7631		6·5499	

TABLE III.

No.	Sq. Rts.	Diff.	C. Rts.	Diff.	No.	Sq. Rts.	Diff.	C. Rts.	Diff.
281	16·7631		6·5499		329	18·1384		6·9034	
282	16·7929	·0298	6·5577	·0078	330	18·1659	·0275	6·9104	·0070
283	16·8226	·0297	6·5654	·0077	331	18·1934	·0275	6·9174	·0070
284	16·8523	·0297	6·5731	·0077	332	18·2209	·0274	6·9244	·0069
285	16·8819	·0296	6·5808	·0077	333	18·2483	·0274	6·9313	·0069
286	16·9115	·0296	6·5885	·0077	334	18·2757	·0273	6·9382	·0069
287	16·9411	·0296	6·5962	·0077	335	18·3030	·0273	6·9451	·0070
288	16·9706	·0295	6·6039	·0076	336	18·3303	·0273	6·9521	·0068
289	17·0000	·0294	6·6115	·0076	337	18·3576	·0272	6·9589	·0069
290	17·0294	·0294	6·6191	·0076	338	18·3848	·0272	6·9658	·0069
291	17·0587	·0293	6·6267	·0076	339	18·4120	·0271	6·9727	·0068
292	17·0880	·0293	6·6343	·0076	340	18·4391	·0271	6·9795	·0069
293	17·1172	·0292	6·6419	·0075	341	18·4662	·0270	6·9864	·0068
294	17·1464	·0292	6·6494	·0075	342	18·4932	·0271	6·9932	·0068
295	17·1756	·0292	6·6569	·0075	343	18·5203	·0269	7·0000	·0068
296	17·2047	·0291	6·6644	·0075	344	18·5472	·0270	7·0068	·0068
297	17·2337	·0290	6·6719	·0075	345	18·5742	·0269	7·0136	·0067
298	17·2627	·0290	6·6794	·0075	346	18·6011	·0268	7·0203	·0068
299	17·2916	·0289	6·6869	·0074	347	18·6279	·0269	7·0271	·0067
300	17·3205	·0289	6·6943	·0075	348	18·6548	·0267	7·0338	·0068
301	17·3494	·0287	6·7018	·0074	349	18·6815	·0268	7·0406	·0067
302	17·3781	·0288	6·7092	·0074	350	18·7083	·0267	7·0473	·0067
303	17·4069	·0287	6·7166	·0074	351	18·7350	·0267	7·0540	·0067
304	17·4356	·0286	6·7240	·0073	352	18·7617	·0266	7·0607	·0067
305	17·4642	·0287	6·7313	·0074	353	18·7883	·0266	7·0674	·0066
306	17·4929	·0285	6·7387	·0073	354	18·8149	·0265	7·0740	·0067
307	17·5214	·0285	6·7460	·0073	355	18·8414	·0266	7·0807	·0066
308	17·5499	·0285	6·7533	·0073	356	18·8680	·0264	7·0873	·0067
309	17·5784	·0284	6·7606	·0073	357	18·8944	·0265	7·0940	·0066
310	17·6068	·0284	6·7679	·0073	358	18·9209	·0264	7·1006	·0066
311	17·6352	·0283	6·7752	·0072	359	18·9473	·0264	7·1072	·0066
312	17·6635	·0283	6·7824	·0073	360	18·9737	·0263	7·1138	·0066
313	17·6918	·0282	6·7897	·0072	361	19·0000	·0262	7·1204	·0065
314	17·7200	·0282	6·7969	·0072	362	19·0263	·0263	7·1269	·0066
315	17·7482	·0282	6·8041	·0072	363	19·0526	·0262	7·1335	·0065
316	17·7764	·0281	6·8113	·0072	364	19·0788	·0262	7·1400	·0066
317	17·8045	·0281	6·8185	·0071	365	19·1050	·0261	7·1466	·0065
318	17·8326	·0280	6·8256	·0072	366	19·1311	·0261	7·1531	·0065
319	17·8606	·0279	6·8328	·0071	367	19·1572	·0261	7·1596	·0065
320	17·8885	·0280	6·8399	·0071	368	19·1833	·0261	7·1661	·0065
321	17·9165	·0279	6·8470	·0071	369	19·2094	·0260	7·1726	·0065
322	17·9444	·0278	6·8541	·0071	370	19·2354	·0260	7·1791	·0064
323	17·9722	·0278	6·8612	·0071	371	19·2614	·0259	7·1855	·0065
324	18·0000	·0278	6·8683	·0070	372	19·2873	·0259	7·1920	·0064
325	18·0278	·0277	6·8753	·0071	373	19·3132	·0259	7·1984	·0064
326	18·0555	·0276	6·8824	·0070	374	19·3391	·0258	7·2048	·0064
327	18·0831	·0277	6·8894	·0070	375	19·3649	·0258	7·2112	·0065
328	18·1108	·0276	6·8964	·0070	376	19·3907	·0258	7·2177	·0063
329	18·1384		6·9034		377	19·4165		7·2240	

TABLE III.

No.	Sq. Rts.	Diff.	C. Rts.	Diff.	No.	Sq. Rts.	Diff.	C. Rts.	Diff.
377	19·4165		7·2240		425	20·6155		7·5185	
378	19·4422	·0257	7·2304	·0064	426	20·6398	·0243	7·5244	·0059
379	19·4679	·0257	7·2368	·0064	427	20·6640	·0242	7·5302	·0058
380	19·4936	·0257	7·2432	·0064	428	20·6882	·0242	7·5361	·0059
381	19·5192	·0256	7·2495	·0063	429	20·7123	·0241	7·5420	·0059
382	19·5448	·0256	7·2558	·0063	430	20·7364	·0241	7·5478	·0058
383	19·5704	·0256	7·2622	·0064	431	20·7605	·0241	7·5537	·0059
384	19·5959	·0255	7·2685	·0063	432	20·7846	·0241	7·5595	·0058
385	19·6214	·0255	7·2748	·0063	433	20·8087	·0241	7·5654	·0059
386	19·6469	·0255	7·2811	·0063	434	20·8327	·0240	7·5712	·0058
387	19·6723	·0254	7·2874	·0063	435	20·8567	·0240	7·5770	·0058
388	19·6977	·0254	7·2936	·0062	436	20·8806	·0239	7·5828	·0058
389	19·7231	·0254	7·2999	·0063	437	20·9045	·0239	7·5886	·0058
390	19·7484	·0253	7·3061	·0062	438	20·9284	·0239	7·5944	·0058
391	19·7737	·0253	7·3124	·0063	439	20·9523	·0239	7·6001	·0057
392	19·7990	·0253	7·3186	·0062	440	20·9762	·0238	7·6059	·0058
393	19·8242	·0252	7·3248	·0062	441	21·0000	·0238	7·6117	·0058
394	19·8494	·0252	7·3310	·0062	442	21·0238	·0238	7·6174	·0057
395	19·8746	·0252	7·3372	·0062	443	21·0476	·0238	7·6232	·0058
396	19·8997	·0251	7·3434	·0062	444	21·0713	·0237	7·6289	·0057
397	19·9249	·0252	7·3496	·0062	445	21·0950	·0237	7·6346	·0057
398	19·9499	·0250	7·3558	·0062	446	21·1187	·0237	7·6403	·0057
399	19·9750	·0251	7·3619	·0061	447	21·1424	·0237	7·6460	·0057
400	20·0000	·0250	7·3681	·0062	448	21·1660	·0236	7·6517	·0057
401	20·0250	·0250	7·3742	·0061	449	21·1896	·0236	7·6574	·0057
402	20·0499	·0249	7·3803	·0061	450	21·2132	·0236	7·6631	·0057
403	20·0749	·0250	7·3864	·0061	451	21·2368	·0236	7·6688	·0057
404	20·0998	·0249	7·3925	·0061	452	21·2603	·0235	7·6744	·0056
405	20·1246	·0248	7·3986	·0061	453	21·2838	·0235	7·6801	·0057
406	20·1494	·0248	7·4047	·0061	454	21·3073	·0235	7·6857	·0056
407	20·1742	·0248	7·4108	·0061	455	21·3307	·0234	7·6914	·0057
408	20·1990	·0248	7·4169	·0061	456	21·3542	·0235	7·6970	·0056
409	20·2237	·0247	7·4229	·0060	457	21·3776	·0234	7·7026	·0056
410	20·2485	·0248	7·4290	·0061	458	21·4009	·0233	7·7082	·0056
411	20 2731	·0246	7·4350	·0060	459	21·4243	·0234	7·7138	·0056
412	20·2978	·0247	7·4410	·0060	460	21·4476	·0233	7·7194	·0056
413	20·3224	·0246	7·4470	·0060	461	21·4709	·0233	7·7250	·0056
414	20·3470	·0246	7·4530	·0060	462	21·4942	·0233	7·7306	·0056
415	20·3715	·0245	7·4590	·0060	463	21·5174	·0232	7·7362	·0056
416	20·3961	·0246	7·4650	·0060	464	21·5407	·0233	7·7418	·0056
417	20·4206	·0245	7·4710	·0060	465	21·5639	·0232	7·7473	·0055
418	20·4450	·0244	7·4770	·0060	466	21·5870	·0231	7·7529	·0056
419	20·4695	·0245	7·4829	·0059	467	21·6102	·0232	7·7584	·0055
420	20·4939	·0244	7·4889	·0060	468	21·6333	·0231	7·7639	·0055
421	20·5183	·0244	7·4948	·0059	469	21·6564	·0231	7·7695	·0056
422	20·5426	·0243	7·5007	·0059	470	21·6795	·0231	7·7750	·0055
423	20·5670	·0244	7·5067	·0060	471	21·7025	·0230	7·7805	·0055
424	20·5913	·0243	7·5126	·0059	472	21·7256	·0231	7·7860	·0055
425	20·6155	·0242	7·5185	·0059	473	21·7486	·0230	7·7915	

TABLE III.

No.	Sq. Rts.	Diff.	C. Rts.	Diff.	No.	Sq. Rts.	Diff.	C. Rts.	Diff.
473	21·7486	·0229	7·7915	·0055	521	22·8254	·0219	8·0466	·0051
474	21·7715	·0230	7·7970	·0055	522	22·8473	·0219	8·0517	·0051
475	21·7945	·0229	7·8025	·0054	523	22·8692	·0218	8·0569	·0051
476	21·8174	·0229	7·8079	·0055	524	22·8910	·0219	8·0620	·0051
477	21·8403	·0229	7·8134	·0054	525	22·9129	·0218	8·0671	·0052
478	21·8632	·0229	7·8188	·0055	526	22·9347	·0218	8·0723	·0051
479	21·8861	·0228	7·8243	·0054	527	22·9565	·0218	8·0774	·0051
480	21·9089	·0228	7·8297	·0055	528	22·9783	·0217	8·0825	·0051
481	21·9317	·0228	7·8352	·0054	529	23·0000	·0217	8·0876	·0051
482	21·9545	·0228	7·8406	·0054	530	23·0217	·0217	8·0927	·0051
483	21·9773	·0228	7·8460	·0054	531	23·0434	·0217	8·0978	·0050
484	22·0000	·0227	7·8514	·0054	532	23·0651	·0216	8·1028	·0051
485	22·0227	·0227	7·8568	·0054	533	23·0868	·0216	8·1079	·0051
486	22·0454	·0227	7·8622	·0054	534	23·1084	·0217	8·1130	·0050
487	22·0681	·0226	7·8676	·0054	535	23·1301	·0216	8·1180	·0051
488	22·0907	·0226	7·8730	·0054	536	23·1517	·0216	8·1231	·0050
489	22·1133	·0226	7·8784	·0053	537	23·1733	·0215	8·1281	·0051
490	22·1359	·0226	7·8837	·0054	538	23·1948	·0216	8·1332	·0050
491	22·1585	·0226	7·8891	·0053	539	23·2164	·0215	8·1382	·0051
492	22·1811	·0225	7·8944	·0054	540	23·2379	·0215	8·1433	·0050
493	22·2036	·0225	7·8998	·0053	541	23·2594	·0215	8·1483	·0050
494	22·2261	·0225	7·9051	·0054	542	23·2809	·0215	8·1533	·0050
495	22·2486	·0225	7·9105	·0053	543	23·3024	·0214	8·1583	·0050
496	22·2711	·0224	7·9158	·0053	544	23·3238	·0214	8·1633	·0050
497	22·2935	·0224	7·9211	·0053	545	23·3452	·0214	8·1683	·0050
498	22·3159	·0224	7·9264	·0053	546	23·3666	·0214	8·1733	·0050
499	22·3383	·0224	7·9317	·0053	547	23·3880	·0214	8·1783	·0050
500	22·3607	·0223	7·9370	·0053	548	23·4094	·0213	8·1833	·0049
501	22·3830	·0224	7·9423	·0053	549	23·4307	·0214	8·1882	·0050
502	22·4054	·0223	7·9476	·0052	550	23·4521	·0213	8·1932	·0050
503	22·4277	·0222	7·9528	·0053	551	23·4734	·0213	8·1982	·0049
504	22·4499	·0223	7·9581	·0053	552	23·4947	·0213	8·2031	·0050
505	22·4722	·0222	7·9634	·0052	553	23·5160	·0212	8·2081	·0049
506	22·4944	·0223	7·9686	·0053	554	23·5372	·0212	8·2130	·0050
507	22·5167	·0222	7·9739	·0052	555	23·5584	·0213	8·2180	·0049
508	22·5389	·0221	7·9791	·0052	556	23·5797	·0211	8·2229	·0049
509	22·5610	·0222	7·9843	·0053	557	23·6008	·0212	8·2278	·0049
510	22·5832	·0221	7·9896	·0052	558	23·6220	·0212	8·2327	·0050
511	22·6053	·0221	7·9948	·0052	559	23·6432	·0211	8·2377	·0049
512	22·6274	·0221	8·0000	·0052	560	23·6643	·0211	8·2426	·0049
513	22·6495	·0221	8·0052	·0052	561	23·6854	·0211	8·2475	·0049
514	22·6716	·0220	8·0104	·0052	562	23·7065	·0211	8·2524	·0049
515	22·6936	·0220	8·0156	·0052	563	23·7276	·0211	8·2573	·0048
516	22·7156	·0220	8·0208	·0052	564	23·7487	·0210	8·2621	·0049
517	22·7376	·0220	8·0260	·0051	565	23·7697	·0211	8·2670	·0049
518	22·7596	·0220	8·0311	·0052	566	23·7908	·0210	8·2719	·0049
519	22·7816	·0219	8·0363	·0052	567	23·8118	·0210	8·2768	·0048
520	22·8035	·0219	8·0415	·0051	568	23·8328	·0209	8·2816	·0049
521	22·8254		8·0466		569	23·8537		8·2865	

TABLE III.

No.	Sq. Rts.	Diff.	C. Rts.	Diff.	No.	Sq. Rts.	Diff.	C. Rts.	Diff.
569	23·8537		8·2865		617	24·8395		8·5132	
570	23·8747	·0210	8·2913	·0048	618	24·8596	·0201	8·5178	·0046
571	23·8956	·0209	8·2962	·0049	619	24·8797	·0201	8·5224	·0046
572	23·9165	·0209	8·3010	·0048	620	24·8998	·0201	8·5270	·0046
573	23·9374	·0209	8·3059	·0049	621	24·9199	·0201	8·5316	·0046
574	23·9583	·0209	8·3107	·0048	622	24·9399	·0200	8·5362	·0046
575	23·9792	·0209	8·3155	·0048	623	24·9600	·0200	8·5408	·0045
576	24·0000	·0208	8·3203	·0048	624	24·9800	·0200	8·5453	·0046
577	24·0208	·0208	8·3251	·0048	625	25·0000	·0200	8·5499	·0045
578	24·0416	·0208	8·3300	·0049	626	25 0200	·0200	8·5544	·0046
579	24·0624	·0208	8·3348	·0048	627	25·0400	·0200	8·5590	·0045
580	24·0832	·0208	8·3396	·0048	628	25·0599	·0199	8·5635	·0046
581	24·1039	·0207	8·3443	·0047	629	25·0799	·0200	8·5681	·0045
582	24·1247	·0208	8·3491	·0048	630	25·0998	·0199	8·5726	·0046
583	24·1454	·0207	8·3539	·0048	631	25·1197	·0199	8·5772	·0045
584	24·1661	·0207	8·3587	·0048	632	25·1396	·0199	8·5817	·0045
585	24·1868	·0207	8·3634	·0047	633	25·1595	·0199	8·5862	·0045
586	24·2074	·0206	8·3682	·0048	634	25·1794	·0199	8·5907	·0045
587	24·2281	·0207	8·3730	·0048	635	25·1992	·0198	8·5952	·0045
588	24·2487	·0206	8·3777	·0047	636	25·2190	·0198	8·5997	·0046
589	24·2693	·0206	8·3825	·0048	637	25·2389	·0199	8·6043	·0045
590	24·2899	·0206	8·3872	·0047	638	25·2587	·0198	8·6088	·0044
591	24·3105	·0206	8·3919	·0047	639	25·2784	·0197	8·6132	·0045
592	24·3311	·0206	8·3967	·0048	640	25·2982	·0198	8·6177	·0045
593	24·3516	·0205	8·4014	·0047	641	25·3180	·0198	8·6222	·0045
594	24·3721	·0205	8·4061	·0047	642	25·3377	·0197	8·6267	·0045
595	24·3926	·0205	8·4108	·0047	643	25·3574	·0197	8·6312	·0045
596	24·4131	·0205	8·4155	·0047	644	25·3772	·0198	8·6357	·0044
597	24·4336	·0205	8·4202	·0047	645	25·3969	·0197	8·6401	·0045
598	24·4540	·0204	8·4249	·0047	646	25·4165	·0196	8·6446	·0044
599	24·4745	·0205	8·4296	·0047	647	25·4362	·0197	8·6490	·0045
600	24·4949	·0204	8·4343	·0047	648	25·4558	·0196	8·6535	·0044
601	24·5153	·0204	8·4390	·0047	649	25·4754	·0196	8·6579	·0045
602	24·5357	·0204	8·4437	·0047	650	25·4951	·0197	8·6624	·0044
603	24·5561	·0204	8·4484	·0047	651	25·5147	·0196	8·6668	·0045
604	24·5764	·0203	8·4530	·0046	652	25·5343	·0196	8·6713	·0044
605	24·5967	·0203	8·4577	·0047	653	25·5539	·0196	8·6757	·0044
606	24·6171	·0204	8·4623	·0046	654	25·5734	·0195	8·6801	·0044
607	24·6374	·0203	8·4670	·0047	655	25·5930	·0196	8·6845	·0045
608	24·6577	·0203	8·4716	·0046	656	25·6125	·0195	8·6890	·0044
609	24·6779	·0202	8·4763	·0047	657	25·6320	·0195	8·6934	·0044
610	24·6982	·0203	8·4809	·0046	658	25·6515	·0195	8·6978	·0044
611	24·7184	·0202	8·4856	·0047	659	25·6710	·0195	8·7022	·0044
612	24·7386	·0202	8·4902	·0046	660	25·6905	·0195	8·7066	·0044
613	24·7588	·0202	8·4948	·0046	661	25·7099	·0194	8·7110	·0044
614	24·7790	·0202	8·4994	·0046	662	25·7294	·0195	8·7154	·0044
615	24·7992	·0202	8·5040	·0046	663	25·7488	·0194	8·7198	·0043
616	24·8193	·0201	8·5086	·0046	664	25·7682	·0194	8·7241	·0044
617	24·8395	·0202	8·5132	·0046	665	25·7876	·0194	8·7285	

TABLE III.

No.	Sq. Rts.	Diff.	C. Rts.	Diff.	No.	Sq. Rts.	Diff.	C. Rts.	Diff.
665	25·7876	·0194	8·7285	·0044	713	26·7021	·0187	8·9337	·0041
666	25·8070	·0193	8·7329	·0044	714	26·7208	·0187	8·9378	·0042
667	25·8263	·0194	8·7373	·0043	715	26·7395	·0187	8·9420	·0042
668	25·8457	·0193	8·7416	·0044	716	26·7582	·0187	8·9462	·0041
669	25·8650	·0194	8·7460	·0043	717	26·7769	·0186	8·9503	·0042
670	25·8844	·0193	8·7503	·0044	718	26·7955	·0187	8·9545	·0042
671	25·9037	·0193	8·7547	·0043	719	26·8142	·0186	8·9587	·0041
672	25·9230	·0192	8·7590	·0044	720	26·8328	·0186	8·9628	·0042
673	25·9422	·0193	8·7634	·0043	721	26·8514	·0187	8·9670	·0041
674	25 9615	·0193	8·7677	·0044	722	26·8701	·0186	8·9711	·0041
675	25·9808	·0192	8·7721	·0043	723	26·8887	·0185	8·9752	·0042
676	26·0000	·0192	8·7764	·0043	724	26·9072	·0186	8·9794	·0041
677	26·0192	·0192	8·7807	·0043	725	26·9258	·0186	8·9835	·0041
678	26·0384	·0192	8·7850	·0043	726	26·9444	·0185	8·9876	·0042
679	26·0576	·0192	8·7893	·0044	727	26·9629	·0186	8·9918	·0041
680	26·0768	·0192	8·7937	·0043	728	26·9815	·0185	8·9959	·0041
681	26·0960	·0191	8·7980	·0043	729	27·0000	·0185	9·0000	·0041
682	26·1151	·0192	8·8023	·0043	730	27·0185	·0185	9·0041	·0041
683	26·1343	·0191	8·8066	·0043	731	27·0370	·0185	9·0082	·0041
684	26·1534	·0191	8·8109	·0043	732	27·0555	·0185	9·0123	·0041
685	26·1725	·0191	8·8152	·0042	733	27·0740	·0184	9·0164	·0041
686	26·1916	·0191	8·8194	·0043	734	27·0924	·0185	9·0205	·0041
687	26·2107	·0191	8·8237	·0043	735	27·1109	·0184	9·0246	·0041
688	26·2298	·0190	8·8280	·0043	736	27·1293	·0184	9·0287	·0041
689	26·2488	·0191	8·8323	·0043	737	27·1477	·0185	9·0328	·0041
690	26·2679	·0190	8·8366	·0042	738	27·1662	·0184	9·0369	·0041
691	26·2869	·0190	8·8408	·0043	739	27·1846	·0183	9·0410	·0040
692	26·3059	·0190	8·8451	·0042	740	27·2029	·0184	9·0450	·0041
693	26·3249	·0190	8·8493	·0043	741	27·2213	·0184	9·0491	·0041
694	26·3439	·0190	8·8536	·0042	742	27·2397	·0183	9·0532	·0040
695	26·3629	·0189	8·8578	·0043	743	27·2580	·0184	9·0572	·0041
696	26·3818	·0190	8·8621	·0042	744	27·2764	·0183	9·0613	·0041
697	26·4008	·0189	8·8663	·0043	745	27·2947	·0183	9·0654	·0040
698	26·4197	·0189	8·8706	·0042	746	27·3130	·0183	9·0694	·0041
699	26·4386	·0189	8·8748	·0042	747	27·3313	·0183	9·0735	·0040
700	26·4575	·0189	8·8790	·0043	748	27·3496	·0183	9·0775	·0041
701	26·4764	·0189	8·8833	·0042	749	27·3679	·0182	9·0816	·0040
702	26·4953	·0188	8·8875	·0042	750	27·3861	·0183	9·0856	·0040
703	26·5141	·0189	8·8917	·0042	751	27·4044	·0182	9·0896	·0041
704	26·5330	·0188	8·8959	·0042	752	27·4226	·0182	9·0937	·0040
705	26·5518	·0189	8·9001	·0042	753	27·4408	·0183	9·0977	·0040
706	26·5707	·0188	8·9043	·0042	754	27·4591	·0182	9·1017	·0040
707	26·5895	·0188	8·9085	·0042	755	27·4773	·0182	9·1057	·0041
708	26·6083	·0188	8·9127	·0042	756	27·4955	·0181	9·1098	·0040
709	26·6271	·0187	8·9169	·0042	757	27·5136	·0182	9·1138	·0040
710	26·6458	·0188	8·9211	·0042	758	27·5318	·0182	9·1178	·0040
711	26·6646	·0187	8·9253	·0042	759	27·5500	·0181	9·1218	·0040
712	26·6833	·0188	8·9295	·0042	760	27·5681	·0181	9·1258	·0040
713	26·7021		8·9337		761	27·5862		9·1298	

TABLE III.

No.	Sq. Rts.	Diff.	C. Rts.	Diff.	No.	Sq. Rts.	Diff.	C. Rts.	Diff.
761	27·5862		9·1298		809	28·4429		9·3179	
762	27·6043	·0181	9·1338	·0040	810	28·4605	·0176	9·3217	·0038
763	27·6225	·0182	9·1378	·0040	811	28·4781	·0176	9·3255	·0038
764	27·6405	·0180	9·1418	·0040	812	28·4956	·0175	9·3294	·0039
765	27·6586	·0181	9·1458	·0040	813	28·5132	·0176	9·3332	·0038
766	27·6767	·0181	9·1498	·0040	814	28·5307	·0175	9·3370	·0038
767	27·6948	·0181	9·1537	·0039	815	28·5482	·0175	9·3408	·0038
768	27·7128	·0180	9·1577	·0040	816	28·5657	·0175	9·3447	·0039
769	27·7308	·0180	9·1617	·0040	817	28·5832	·0175	9·3485	·0038
770	27·7489	·0181	9·1657	·0040	818	28 6007	·0175	9·3523	·0038
771	27·7669	·0180	9·1696	·0039	819	28·6182	·0175	9·3561	·0038
772	27·7849	·0180	9·1736	·0040	820	28·6356	·0174	9·3599	·0038
773	27·8029	·0180	9·1775	·0039	821	28·6531	·0175	9·3637	·0038
774	27·8209	·0180	9·1815	·0040	822	28·6705	·0174	9·3675	·0038
775	27·8388	·0179	9·1855	·0040	823	28·6880	·0175	9·3713	·0038
776	27·8568	·0180	9·1894	·0039	824	28·7054	·0174	9·3751	·0038
777	27·8747	·0179	9·1933	·0039	825	28·7228	·0174	9·3789	·0038
778	27·8927	·0180	9·1973	·0040	826	28·7402	·0174	9·3827	·0038
779	27·9106	·0179	9·2012	·0039	827	28·7576	·0174	9·3865	·0038
780	27·9285	·0179	9·2052	·0040	828	28·7750	·0174	9·3902	·0037
781	27·9464	·0179	9·2091	·0039	829	28·7924	·0174	9·3940	·0038
782	27·9643	·0179	9·2130	·0039	830	28·8097	·0173	9·3978	·0038
783	27·9821	·0178	9·2170	·0040	831	28·8271	·0174	9·4016	·0038
784	28·0000	·0179	9·2209	·0039	832	28·8444	·0173	9·4053	·0037
785	28·0179	·0179	9·2248	·0039	833	28·8617	·0173	9·4091	·0038
786	28·0357	·0178	9·2287	·0039	834	28·8791	·0174	9·4129	·0038
787	28·0535	·0178	9·2326	·0039	835	28·8964	·0173	9·4166	·0037
788	28·0713	·0178	9·2365	·0039	836	28·9137	·0173	9·4204	·0038
789	28·0891	·0178	9·2404	·0039	837	28·9310	·0173	9·4241	·0037
790	28·1069	·0178	9·2443	·0039	838	28·9482	·0172	9·4279	·0038
791	28·1247	·0178	9·2482	·0039	839	28 9655	·0173	9·4316	·0037
792	28·1425	·0178	9·2521	·0039	840	28·9828	·0173	9·4354	·0038
793	28·1603	·0178	9·2560	·0039	841	29·0000	·0172	9·4391	·0037
794	28·1780	·0177	9·2599	·0089	842	29·0172	·0172	9·4429	·0038
795	28·1957	·0177	9·2638	·0039	843	29·0345	·0173	9·4466	·0037
796	28·2135	·0178	9·2677	·0039	844	29·0517	·0172	9·4503	·0037
797	28·2312	·0177	9·2716	·0039	845	29·0689	·0172	9·4541	·0037
798	28·2489	·0177	9·2754	·0038	846	29·0861	·0172	9·4578	·0037
799	28·2666	·0177	9·2793	·0039	847	29·1033	·0172	9·4615	·0037
800	28·2843	·0177	9·2832	·0039	848	29·1204	·0171	9·4652	·0037
801	28 3019	·0176	9·2870	·0038	849	29·1376	·0172	9·4690	·0038
802	28·3196	·0177	9·2909	·0039	850	29·1548	·0172	9·4727	·0037
803	28·3373	·0177	9·2948	·0039	851	29·1719	·0171	9·4764	·0037
804	28·3549	·0176	9·2986	·0038	852	29·1890	·0171	9·4801	·0037
805	28·3725	·0176	9·3025	·0039	853	29·2062	·0172	9·4838	·0037
806	28·3901	·0176	9·3063	·0038	854	29·2233	·0171	9·4875	·0037
807	28·4077	·0176	9·3102	·0039	855	29·2404	·0171	9·4912	·0037
808	28·4253	·0176	9·3140	·0038	856	29·2575	·0171	9·4949	·0037
809	28·4429	·0176	9·3179	·0039	857	29·2746	·0171	9·4986	·0037

TABLE III.

No.	Sq. Rts.	Diff.	C. Rts.	Diff.	No.	Sq. Rts.	Diff.	C. Rts.	Diff.
857	29·2746		9·4986		905	30·0832		9·6727	
858	29·2916	·0170	9·5023	·0037	906	30·0998	·0166	9·6763	·0036
859	29·3087	·0171	9·5060	·0037	907	30·1164	·0166	9·6799	·0036
860	29·3258	·0171	9·5097	·0037	908	30·1330	·0166	9·6834	·0035
861	29·3428	·0170	9·5134	·0037	909	30·1496	·0166	9·6870	·0036
862	29·3598	·0170	9·5171	·0037	910	30·1662	·0166	9·6905	·0035
863	29·3769	·0171	9·5207	·0036	911	30·1828	·0166	9·6941	·0036
864	29·3939	·0170	9·5244	·0037	912	30·1993	·0165	9·6976	·0035
865	29·4109	·0170	9·5281	·0037	913	30·2159	·0166	9·7012	·0036
866	29·4279	·0170	9·5317	·0036	914	30·2324	·0165	9·7047	·0035
867	29·4449	·0170	9·5354	·0037	915	30·2490	·0166	9·7082	·0035
868	29·4618	·0169	9·5391	·0037	916	30·2655	·0165	9·7118	·0036
869	29·4788	·0170	9·5427	·0036	917	30·2820	·0165	9·7153	·0035
870	29·4958	·0170	9·5464	·0037	918	30·2985	·0165	9·7188	·0035
871	29·5127	·0169	9·5501	·0037	919	30·3150	·0165	9·7224	·0036
872	29·5296	·0169	9·5537	·0036	920	30·3315	·0165	9·7259	·0035
873	29·5466	0170	9·5574	·0037	921	30·3480	·0165	9·7294	·0035
874	29·5635	·0169	9·5610	·0036	922	30·3645	·0165	9·7329	·0035
875	29·5804	·0169	9·5647	·0037	923	30·3809	·0164	9·7364	·0035
876	29·5973	·0169	9·5683	·0036	924	30·3974	·0165	9·7400	·0036
877	29·6142	·0169	9·5719	·0036	925	30·4138	·0164	9·7435	·0035
878	29 6311	·0169	9·5756	·0037	926	30·4302	·0164	9·7470	·0035
879	29·6479	·0168	9·5792	·0036	927	30·4467	·0165	9·7505	·0035
880	29·6648	·0169	9·5828	·0036	928	30·4631	·0164	9·7540	·0035
881	29·6816	·0168	9·5865	·0037	929	30·4795	·0164	9·7575	·0035
882	29·6985	·0169	9·5901	·0036	930	30·4959	·0164	9·7610	·0035
883	29·7153	·0168	9·5937	·0036	931	30·5123	·0164	9·7645	·0035
884	29·7321	·0168	9·5973	·0036	932	30·5287	·0164	9·7680	·0035
885	29·7489	·0168	9·6010	·0037	933	30·5450	·0163	9·7715	·0035
886	29·7658	·0169	9·6046	·0036	934	30·5614	·0164	9·7750	·0035
887	29·7825	·0167	9·6082	·0036	935	30·5778	·0164	9·7785	·0035
888	29·7993	·0168	9·6118	·0036	936	30·5941	·0163	9·7819	·0034
889	29·8161	·0168	9·6154	·0036	937	30·6105	·0164	9·7854	·0035
890	29·8329	·0168	9·6190	·0036	938	30·6268	·0163	9·7889	·0035
891	29·8496	·0167	9·6226	·0036	939	30·6431	·0163	9·7924	·0035
892	29·8664	·0168	9·6262	·0036	940	30·6594	·0163	9·7959	·0035
893	29·8831	·0167	9·6298	·0036	941	30·6757	·0163	9 7993	·0034
894	29·8998	·0167	9·6334	·0036	942	30·6920	·0163	9·8028	·0035
895	29·9166	·0168	9·6370	·0036	943	30·7083	·0163	9·8063	·0035
896	29·9333	·0167	9·6406	·0036	944	30·7246	·0163	9·8097	·0034
897	29·9500	·0167	9·6442	·0036	945	30·7409	·0163	9·8132	·0035
898	29·9666	·0166	9·6477	·0035	946	30·7571	·0162	9·8167	·0035
899	29·9833	·0167	9·6513	·0036	947	30·7734	·0163	9·8201	·0034
900	30·0000	·0167	9·6549	·0036	948	30·7896	·0162	9·8236	·0035
901	30·0167	·0167	9·6585	·0036	949	30·8058	·0162	9·8270	·0034
902	30·0333	·0166	9·6620	·0035	950	30·8221	·0163	9·8305	·0035
903	30·0500	·0167	9·6656	·0036	951	30·8383	·0162	9·8339	·0034
904	30·0666	·0166	9·6692	·0036	952	30·8545	·0162	9·8374	·0035
905	30·0832	·0166	9·6727	·0035	953	30·8707	·0162	9·8408	·0034

TABLE III.

No.	Sq. Rts.	Diff.	C. Rts.	Diff.	No.	Sq. Rts.	Diff.	C. Rts.	Diff.
953	30·8707		9·8408		977	31·2570		9·9227	
		·0162		·0035			·0160		·0034
954	30·8869		9·8443		978	31·2730		9·9261	
		·0162		·0034			·0160		·0034
955	30·9031		9·8477		979	31·2890		9·9295	
		·0161		·0034			·0160		·0034
956	30·9192		9·8511		980	31·3050		9·9329	
		·0162		·0035			·0159		·0034
957	30 9354		9·8546		981	31·3209		9·9363	
		·0162		·0034			·0160		·0033
958	30·9516		9·8580		982	31·3369		9·9396	
		·0161		·0034			·0159		·0034
959	30·9677		9·8614		983	31·3528		9·9430	
		·0162		·0034			·0160		·0034
960	30·9839		9·8648		984	31·3688		9·9464	
		·0161		·0035			·0159		·0033
961	31·0000		9·8683		985	31·3847		9 9497	
		·0161		·0034			·0159		·0034
962	31·0161		9·8717		986	31·4006		9·9531	
		·0161		·0034			·0160		·0034
963	31·0322		9·8751		987	31·4166		9·9565	
		·0161		·0034			·0159		·0033
964	31·0483		9·8785		988	31·4325		9·9598	
		·0161		·0034			·0159		·0034
965	31·0644		9·8819		989	31·4484		9·9632	
		·0161		·0035			·0159		·0034
966	31·0805		9·8854		990	31·4643		9·9666	
		·0161		·0034			·0159		·0033
967	31·0966		9·8888		991	31·4802		9·9699	
		·0161		·0034			·0158		·0033
968	31·1127		9·8922		992	31·4960		9·9732	
		·0161		·0034			·0159		·0034
969	31·1288		9·8956		993	31·5119		9·9766	
		·0160		·0034			·0159		·0034
970	31·1448		9·8990		994	31·5278		9·9800	
		·0161		·0034			·0158		·0033
971	31·1609		9·9024		995	31·5436		9·9833	
		·0160		·0034			·0159		·0033
972	31·1769		9·9058		996	31·5595		9·9866	
		·0160		·0034			·0158		·0034
973	31 1929		9·9092		997	31·5753		9·9900	
		·0161		·0034			·0158		·0033
974	31·2090		9·9126		998	31·5911		9·9933	
		·0160		·0034			·0159		·0034
975	31·2250		9·9160		990	31·6070		9·9967	
		·0160		·0034			·0158		·0033
976	31·2410		9·9194		1000	31·6228		10·0000	
		·0160		·0033					
977	31·2570		9·9227						

TO FIND BY THE FOREGOING TABLE THE SQUARE OR CUBE ROOT OF ANY NUMBER NOT EXCEEDING 1000.

RULE.—Multiply the difference between the root of the integer part of the given number, and the root of the next higher integer number, by the decimal part of the given number, and add the product to the root of the integer number given, the sum is the root required.

EXAMPLE 1.—Required the square root of 53·75?

Difference by table = ·0684 × ·75 = ·0513; and the root of 53 = 7·2801; hence, 7·2801 + ·0513 = 7·3314, the root required.

EXAMPLE 2.—Required the cube root of the number 734·26?

Difference by table = ·0041 × ·26 = ·001066; and the root of 734 = 9·0205; hence, 9·0205 + ·001066 = 9·021566 or 9·0216, is the root required.

TABLE IV.

CONTAINING

THE SURFACE AND SOLIDITY OF SPHERES,

THE EDGE OR SIDE OF EQUAL CUBES,

THE LENGTHS OF EQUAL CYLINDERS,

AND THE

WEIGHT OF EQUAL VOLUMES OF WATER IN *LBS.* AVOIRDUPOIS.

TABLE IV.

Dia. in *inches.*	Surface in *sq. in.*	Solidity in *cub. in.*	Cube in *inches.*	Cylinder in *inches.*	Water in *lbs. avoir.*
0 *in.*	*sq. in.*	*cub. in.*	*in.*	*in.*	
1/8	0·0491	0·0010	0·1007	0·0833	0·0000
1/4	0·1963	0·0082	0·2015	0·1667	0·0003
3/8	0·4418	0·0276	0·3022	0·2500	0·0010
1/2	0·7854	0·0654	0·4030	0·3333	0·0024
5/8	1·2272	0·1278	0·5037	0·4167	0·0046
3/4	1·7671	0·2209	0·6045	0·5000	0·0080
7/8	2·4053	0·3508	0·7024	0·5833	0·0127
1 *in.*	3·1416	0·5236	0·8060	0·6667	0·0189
1/8	3·9761	0·7455	0·9067	0·7500	0·0269
1/4	4·9087	1·0227	1·0075	0·8333	0·0369
3/8	5·9396	1·3612	1·1082	0·9167	0·0491
1/2	7·0686	1·7671	1·2090	1·0000	0·0637
5/8	8·2958	2·2468	1·3097	1·0833	0·0810
3/4	9·6211	2·8062	1·4105	1·1667	0·1012
7/8	11·0447	3·4515	1·5112	1·2500	0·1245
2 *in.*	12·5664	4·1888	1·6120	1·3333	0·1511
1/8	14·1863	5·0243	1·7127	1·4167	0·1812
1/4	15·9043	5·9641	1·8135	1·5000	0·2151
3/8	17·7205	7·0144	1·9142	1·5833	0·2530
1/2	19·6350	8·1812	2·0150	1·6667	0·2951
5/8	21·6475	9·4708	2·1157	1·7500	0·3416
3/4	23·7583	10·8892	2·2165	1·8333	0·3927
7/8	25·9672	12·4426	2·3172	1·9166	0·4487
3 *in.*	28·2743	14·1372	2·4180	2·0000	0·5099
1/8	30·6796	15·9790	2·5187	2·0833	0·5778
1/4	33·1831	17·9742	2·6195	2·1667	0·6482
3/8	35·7847	20·1289	2·7202	2·2500	0·7256
1/2	38·4845	22·4493	2·8210	2·3333	0·8096
5/8	41·2825	24·9415	2·9217	2·4167	0·8995
3/4	44·1786	27·6117	3·0225	2·5000	0·9958
7/8	47·1730	30·4659	3·1232	2·5833	1·0988
4 *in.*	50·2655	33·5103	3·2240	2·6667	1·2086
1/8	53·4562	36·7511	3·3247	2·7500	1·3254
1/4	56·7450	40·1944	3·4255	2·8333	1·4496
3/8	60·1320	43·8463	3·5262	2·9166	1·5813
1/2	63·6173	47·7129	3·6270	3·0000	1·7208
5/8	67·2006	51·8005	3·7277	3·0833	1·8682
3/4	70·8822	56·1151	3·8285	3·1667	2·0238
7/8	74·6619	60·6628	3·9292	3·2500	2·1878
5 *in.*	78·5398	65·4498	4·0300	3·3333	2·3605
1/8	82·5159	70·4823	4·1307	3·4167	2·5420
1/4	86·5901	75·7664	4·2315	3·5000	2·7325
3/8	90·7626	81·3081	4·3322	3·5833	2·9324
1/2	95·0332	87·1137	4·4330	3·6667	3·1418
5/8	99·4020	93·1893	4·5337	3·7500	3·3609
3/4	103·8689	99·5410	4·6345	3 8333	3·5900
7/8	108·4340	106·1750	4·7352	3·9167	3·8280

TABLE IV.

Dia. in *inches.*	Surface in *sq. in.*	Solidity in *cub. in.*	Cube in *inches.*	Cylinder in *inches.*	Water in *lbs. avoir.*
6 *in.*	113·0973	113·0973	4·8360	4·0000	4·0789
⅛	117·8588	120·3142	4·9367	4·0833	4·3392
¼	122·7185	127·8317	5·0375	4·1667	4·6228
⅜	127·6763	135·6561	5·1382	4·2500	4·8922
½	132·7323	143·7933	5·2390	4·3333	5·1860
⅝	137·8865	152·2496	5·3397	4·4167	5·4909
¾	143·1388	161·0312	5·4405	4·5000	5·8077
⅞	148·4893	170·1440	5·5412	4·5833	6·1363
7 *in.*	153·9380	179·5944	5·6420	4·6667	6·4771
⅛	159·4849	189·3883	5·7427	4·7500	6·8304
¼	165·1300	199·5320	5·8435	4·8333	7·1962
⅜	170·8732	210·0316	5·9442	4·9167	7·5749
½	176·7146	220·8932	6 0450	5·0000	7·9666
⅝	182·6542	232·1230	6·1457	5·0833	8·3716
¾	188·6919	243·7270	6·2465	5·1667	8·7901
⅞	194·8278	255·7115	6·3472	5·2500	9·2223
8 *in.*	201·0619	268·0826	6·4480	5·3333	9·6685
⅛	207·5942	280·8463	6·5487	5·4167	10·1288
¼	213·8246	294·0089	6·6495	5·5000	10·6036
⅜	220·3533	307·5764	6·7502	5·5833	11·0933
½	226·9801	321·5551	6·8510	5·6667	11·5970
⅝	233·7050	335·9510	6·9517	5·7500	12·1159
¾	240·5282	350·7703	7·0525	5·8333	12·6507
⅞	247·4495	366·0191	7·1532	5·9167	13·2007
9 *in.*	254·4690	381·7035	7·2540	6·0000	13·7663
⅛	261·5867	397·8297	7·3547	6·0833	14·3479
¼	268·8025	414·4039	7·4555	6·1667	14·9457
⅜	276·1165	431·4321	7·5562	6·2500	15·5599
½	283·5287	448·9205	7·6570	6·3333	16·1905
⅝	291·0391	466·8752	7·7577	6·4167	16·8378
¾	298·6477	485·3024	7·8585	6·5000	17·5026
⅞	306·3544	504·2082	7·9592	6·5833	18·1845
10 *in.*	314·1593	523·5988	8·0600	6·6667	18·8838
⅛	322·0623	543·4802	8·1607	6·7500	19·6008
¼	330·0636	563·8586	8·2615	6·8333	20·3358
⅜	338·1630	584·7402	8·3622	6·9167	21·0891
½	346·3606	606·1310	8·4630	7·0000	21·8604
⅝	354·6564	628·0373	8·5637	7·0833	22·6494
¾	363·0503	650·4651	8·6645	7·1667	23·4593
⅞	371·5424	673·4206	8·7652	7·2500	24·2872
11 *in.*	380·1327	696·9100	8·8660	7·3333	25·1344
⅛	388·8212	720·9393	8·9667	7·4167	26·0010
¼	397·6078	745·5147	9·0675	7·5000	26·8873
⅜	406·4926	770·6423	9·1682	7·5833	27·7936
½	415·4756	796·3283	9·2690	7·6667	28·7199
⅝	424·5568	822·5788	9·3697	7·7500	29·6662
¾	433·7361	849·3999	9·4705	7·8333	30·6242
⅞	443·0137	876·7979	9·5712	7·9167	31·6221

TABLE IV.

Dia. in *inches.*	Surface in *sq. in.*	Solidity in *cub. in.*	Cube in *inches.*	Cylinder in *inches.*	Water in *lbs. avoir.*
12 *in.*	452·3893	904·7787	9·6720	8·0000	32·6312
⅛	461·8632	933·3486	9·7727	8·0833	33·6616
¼	471·4352	962·5136	9·8735	8·1667	34·7135
⅜	481·1055	992·2800	9·9742	8·2500	35·7868
½	490·8739	1022·6539	10·0749	8·3333	36·8824
⅝	500·7404	1053·6413	10·1757	8·4167	38·0000
¾	510·7052	1085·2485	10·2764	8·5000	39·1399
⅞	520·7681	1117·4815	10·3772	8·5833	40·3024
13 *in.*	530·9292	1150·3465	10·4779	8·6667	41·4877
⅛	541·1884	1183·8497	10·5787	8·7500	42·6960
¼	551·5459	1217·9971	10·6794	8·8333	43·9276
⅜	562·0015	1252·7950	10·7802	8·9167	45·1828
½	572·5553	1288·2493	10·8809	9·0000	46·4613
⅝	583·2072	1324·3664	10·9817	9·0833	47·7436
¾	593·9574	1361·1523	11·0824	9·1667	49·0905
⅞	604·8057	1398·6131	11·1832	9·2500	50·4416
14 *in.*	615·7522	1436·7550	11·2839	9·3333	51·8172
⅛	626·7968	1475·5842	11·3847	9·4167	53·2176
¼	637·9397	1515·1067	11·4854	9·5000	54·6430
⅜	649·1807	1555·3287	11·5862	9·5833	56·0936
½	660·5199	1596·2563	11·6869	9·6667	57·5697
⅝	671·9572	1637·8957	11·7877	9·7500	59·0716
¾	683·4928	1680·2530	11·8884	9·8333	60·5990
⅞	695·1265	1723·3343	11·9892	9·9167	62·1528
15 *in.*	706·8583	1767·1459	12·0899	10·0000	63·7329
⅛	718·6884	1811·6937	12·1907	10·0833	65·3395
¼	730·6166	1856·9840	12·2914	10·1667	66·9729
⅜	742·6431	1903·0228	12·3922	10·2500	68·6333
½	754·7676	1949·8164	12·4929	10·3333	70·3210
⅝	766·9904	1997·3708	12·5937	10·4167	72·0361
¾	779·3113	2045·6922	12·6944	10·5000	73·7788
⅞	791·7304	2094·7868	12·7952	10·5833	75·5494
16 *in.*	804·2477	2144·6606	12·8959	10·6667	77·3481

EXAMPLES TO TABLE IV.

Ex. 1. Required the surface of a sphere, whose diameter is $4\frac{7}{8}$ *inches?*

Here, in *column* 1, *page* 50, will be found $4\frac{7}{8}$ *inches*, the diameter; against which, in *column* 2, will be found 74·6619 *square inches*, the surface required.

Or by mensuration thus:—multiply the square of the diameter by π, No. 1 of the Table of Useful Numbers, *page* 169;

Here $\pi \times (4\frac{7}{8})^2 = 3{\cdot}1415926 \times (5 - \frac{1}{8})^2 = (15{\cdot}7079630 - {\cdot}3926991) \times (5 - \frac{1}{8}) = 15{\cdot}3152639 \times (5 - \frac{1}{8}) = 76{\cdot}5763195 - 1{\cdot}9144080 = 74{\cdot}6619115$ *square inches as before.*

Ex. 2. Required the solidity of a sphere, whose diameter is $11\frac{3}{8}$ *inches?*

Here, in *column* 1, *page* 51, will be found $11\frac{3}{8}$ *inches*, the diameter; against which, in *column* 3, will be found 770·6423 *cubic inches*, the solid content required.

Or by mensuration thus:—multiply the cube of the diameter by $\frac{1}{6}\pi$, No. 8 of the Table of Useful Numbers, *page* 170;

Here $\frac{1}{6}\pi \times (11\frac{3}{8})^3 = {\cdot}5235988 \times (11 + \frac{1}{4} + \frac{1}{8})^3 = (5{\cdot}7595868 + {\cdot}1308997 + {\cdot}0654498) \times (11 + \frac{1}{4} + \frac{1}{8})^2 = 5{\cdot}9559363 \times (11 + \frac{1}{4} + \frac{1}{8})^2 = (65{\cdot}5152993 + 1{\cdot}4889841 + {\cdot}7444920) \times (11 + \frac{1}{4} + \frac{1}{8}) = 67{\cdot}7487754 \times (11 + \frac{1}{4} + \frac{1}{8}) = 745{\cdot}2365294 + 16{\cdot}9371938 + 8{\cdot}4685969 = 770{\cdot}6423201$ *solid inches as before.*

Ex. 3. What is the length of the edge or side of a cube, equal in volume or solid content to a sphere, whose diameter is $7\frac{5}{8}$ *inches?*

Here, in *column* 1, *page* 51, will be found $7\frac{5}{8}$ *inches*, the diameter; against which, in *column* 4, will be found 6·1457 *inches*, the length required.

Or thus by mensuration:—multiply the diamcter of the sphere by $\sqrt[3]{\frac{\pi}{6}}$, No 66 of the Table of Useful Numbers, *page* 175.

Here $\sqrt[3]{\frac{\pi}{6}} \times 7\frac{5}{8} = {\cdot}805996 \times (7 + \frac{1}{2} + \frac{1}{8}) = 5{\cdot}641972 + {\cdot}402998 + {\cdot}100749 = 6{\cdot}145719$ *inches as before.*

Ex. 4. What is the length of a cylinder of $4\frac{3}{4}$ *inches* diameter, having its volume equal to that of a sphere of the same diameter?

Here, in *column* 1, *page* 50, will be found $4\frac{3}{4}$ *inches*, the diameter; against which, in *column* 5, will be found 3·1667 *inches*, the length required.

Or thus: — two-thirds of the sphere's diameter = height of the cylinder, thus,

From $4\frac{3}{4} = 4{\cdot}75$
Subtract $\frac{1}{3}$ of $4\frac{3}{4} = 1{\cdot}5833$

$3{\cdot}1667$ *inches as before.*

Ex. 5. Required the weight of a quantity of rain water, equal in volume to that of a sphere whose diameter is $15\frac{1}{8}$ *inches?*

Here, in *column* 1, *page* 52, will be found $15\frac{1}{8}$ *inches*, against which, in *column* 6, will be found 65·3395 *lbs. avoirdupois*, the weight required.

Or thus:—find the solidity of the sphere as example 2, which multiply by ·0360654 = 10 times No. 89 of the Table of Useful Numbers *page* 177.

$$\cdot5235988 = \tfrac{1}{6}\pi$$
$$5{\cdot}7595868 = 11 \times \tfrac{1}{6}\pi$$
$$63{\cdot}3554548 = 121 \times \tfrac{1}{6}\pi$$
$$7{\cdot}9194318 = \tfrac{121}{8} \times \tfrac{1}{6}\pi$$
$$87{\cdot}1137498 = 11 \times \tfrac{121}{8} \times \tfrac{1}{6}\pi$$
$$958{\cdot}2512478 = 121 \times \tfrac{121}{8} \times \tfrac{1}{6}\pi$$
$$119{\cdot}7814060 = \left(\tfrac{121}{8}\right)^2 \times \tfrac{1}{6}\pi$$
$$1317{\cdot}5954660 = 11 \times \left(\tfrac{121}{8}\right)^2 \times \tfrac{1}{6}\pi$$
$$14493{\cdot}5501260 = 121 \times \left(\tfrac{121}{8}\right)^2 \times \tfrac{1}{6}\pi$$
$$1811{\cdot}693766 = \left(\tfrac{121}{8}\right)^3 \times \tfrac{1}{6}\pi$$
$$456063 = \text{Const. No. inverted.}$$

54·350813
10·870163
·108702
9058
725

65·339461 *lbs. av.* = *Ans. as before.*

TABLE V.

CONTAINING THE

WEIGHT OF CYLINDRICAL COLUMNS OF WATER,

EACH ONE FOOT IN LENGTH,

AND OF VARIOUS DIAMETERS,

IN *LBS.* AVOIRDUPOIS.

TABLE V.

Dia.	Weight.	Dia.	Weight.	Dia.	Weight.
3 *in.*	3·0592	9 *in.*	27·5326	15 *in.*	76·4794
⅛	3·3194	⅛	28·3027	⅛	77·7594
¼	3·5903	¼	29·0834	¼	79·0500
⅜	3·8718	⅜	29·8748	⅜	80·3512
½	4·1639	½	30·6768	½	81·6631
⅝	4·4666	⅝	31·4894	⅝	82·9855
¾	4·7800	¾	32·3126	¾	84·3186
⅞	5·1039	⅞	33·1464	⅞	85·6623
4 *in.*	5·4385	10 *in.*	33·9909	16 *in.*	87·0166
⅛	5·7838	⅛	34·8459	⅛	88·3816
¼	6·1396	¼	35·7117	¼	89·7571
⅜	6·5061	⅜	36·5880	⅜	91·1433
½	6·8832	½	37·4749	½	92·5401
⅝	7·2709	⅝	38·3725	⅝	93·9476
¾	7·6692	¾	39·2807	¾	95·3656
⅞	8·0781	⅞	40·1995	⅞	96·7943
5 *in.*	8·4977	11 *in.*	41·1289	17 *in.*	98·2336
⅛	8·9279	⅛	42·0690	⅛	99·6835
¼	9·3687	¼	43·0197	¼	101·1441
⅜	9·8202	⅜	43·9810	⅜	102·6152
½	10·2822	½	44·9529	½	104·0970
⅝	10·7549	⅝	45·9355	⅝	105·5894
¾	11·2382	¾	46·9286	¾	107·0925
⅞	11·7322	⅞	47·9324	⅞	108·6061
6 *in.*	12·2367	12 *in.*	48·9468	18 *in.*	110·1304
⅛	12·7519	⅛	49·9719	⅛	111·6653
¼	13·2777	¼	51·0075	¼	113·2108
⅜	13·8141	⅜	52·0538	⅜	114·7670
½	14·3611	½	53·1107	½	116·3337
⅝	14·9188	⅝	54·1783	⅝	117·9111
¾	15·4871	¾	55·2564	¾	119·4991
⅞	16·0660	⅞	56·3452	⅞	121·0978
7 *in.*	16·6555	13 *in.*	57·4446	19 *in.*	122·7070
⅛	17·2557	⅛	58·5546	⅛	124·3369
¼	17·8664	¼	59·6752	¼	125·9574
⅜	18·4878	⅜	60·8065	⅜	127·5985
½	19·1199	½	61·9484	½	129·2503
⅝	19·7625	⅝	63·1009	⅝	130·9126
¾	20·4158	¾	64·2640	¾	132·5856
⅞	21·0796	⅞	65·4377	⅞	134·2692
8 *in.*	21·7542	14 *in.*	66·6221	20 *in.*	135·9635
⅛	22·4393	⅛	67·8171	⅛	137·6683
¼	23·1350	¼	69·0227	¼	139·3838
⅜	23·8414	⅜	70·2389	⅜	141·1099
½	24·5584	½	71·4658	½	142·8466
⅝	25·2860	⅝	72·7033	⅝	144·5940
¾	26·0243	¾	73·9514	¾	146·3519
⅞	26·7731	⅞	75·2101	⅞	148·1205

TABLE V.

Dia.	Weight.	Dia.	Weight.	Dia.	Weight.
21 *in.*	149·8997	27 *in.*	247·7934	33 *in.*	370·1605
⅛	151·6895	⅛	250·0931	⅛	372·9701
¼	153·4900	¼	252·4034	¼	375·7903
⅜	155·3011	⅜	254·7244	⅜	378·6211
½	157·1228	½	257·0559	½	381·4625
⅝	158·9551	⅝	259·3981	⅝	384·3145
¾	160·7980	¾	261·7509	¾	387·1772
⅞	162·6516	⅞	264·1143	⅞	390·0505
22 *in.*	164·5158	28 *in.*	266·4884	34 *in.*	392·9344
⅛	166·3906	⅛	268·8731	⅛	395·8289
¼	168·2760	¼	271·2684	¼	398·7341
⅜	170·1721	⅜	273·6743	⅜	401·6499
½	172·0788	½	276·0908	½	404·5763
⅝	173·9961	⅝	278·5180	⅝	407·5133
¾	175·9240	¾	280·9557	¾	410·4609
⅞	177·8625	⅞	283·4042	⅞	413·4192
23 *in.*	179·8117	29 *in.*	285·8632	35 *in.*	416·3881
⅛	181·7715	⅛	288·3328	⅛	419·3676
¼	183·7419	¼	290·8131	¼	422·3577
⅜	185·7229	⅜	293·3040	⅜	425·3585
½	187·7146	½	295·8055	½	428·3699
⅝	189·7168	⅝	298·3176	⅝	431·3919
¾	191·7297	¾	300·8404	¾	434·4245
⅞	193·7532	⅞	303·3738	⅞	437·4678
24 *in.*	195·7874	30 *in.*	305·9178	36 *in.*	440·5216
⅛	197·8321	⅛	308·4724	⅛	443·5861
¼	199·8875	¼	311·0377	¼	446·6612
⅜	201·9535	⅜	313·6135	⅜	449·7470
½	204·0302	½	316·2000	½	452·8433
⅝	206·1174	⅝	318·7971	⅝	455·9503
¾	208·2153	¾	321·4049	¾	459·0679
⅞	210·3238	⅞	324·0232	⅞	462·1961
25 *in.*	212·4429	31 *in.*	326·6522	37 *in.*	465·3350
⅛	214·5727	⅛	329·2918	⅛	468·4844
¼	216·7130	¼	331·9420	¼	471·6445
⅜	218·8640	⅜	334·6029	⅜	474·8152
½	221·0256	½	337·2744	½	477·9965
⅝	223·1978	⅝	339·9565	⅝	481·1885
¾	225·3807	¾	342·6492	¾	484·3911
⅞	227·5742	⅞	345·3525	⅞	487·6043
26 *in.*	229·7783	32 *in.*	348·0665	38 *in.*	490·8281
⅛	231·9930	⅛	350·7910	⅛	494·0625
¼	234·2183	¼	353·5262	¼	497·3076
⅜	236·4543	⅜	356·2721	⅜	500·5633
½	238·7009	½	359·0285	½	503·8296
⅝	240·9581	⅝	361·7956	⅝	507·1065
¾	243·2259	¾	364·5733	¾	510·3941
⅞	245·5043	⅞	367·3616	⅞	513·6923

TABLE V.

Dia.	Weight.	Dia.	Weight.	Dia.	Weight.
39 *in.*	517·0011	43 *in.*	628·4911	47 *in.*	750·8582
⅛	520·3205	⅛	632·1504	⅛	754·8575
¼	523·6505	¼	635·8204	¼	758·8673
⅜	526·9912	⅜	639·5010	⅜	762·8878
½	530·3425	½	643·1922	½	766·9189
⅝	533·7044	⅝	646·8940	⅝	770·9606
¾	537·0769	¾	650·6064	¾	775·0130
⅞	540·4601	⅞	654·3295	⅞	779·0760
40 *in.*	543·8539	44 *in.*	658·0632	48 *in.*	783·1495
⅛	547·2582	⅛	661·8075	⅛	787·2338
¼	550·6733	¼	665·5624	¼	791·3286
⅜	554·0989	⅜	669·3279	⅜	795·4341
½	557·5352	½	673·1041	½	799·5501
⅝	560·9821	⅝	676·8909	⅝	803·6768
¾	564·4396	¾	680·6883	¾	807·8142
⅞	567·9077	⅞	684·4964	⅞	811·9621
41 *in.*	571·3865	45 *in.*	688·3150	49 *in.*	816·1207
⅛	574·8758	⅛	692·1443	⅛	820·2899
¼	578·3758	¼	695·9842	¼	824·4697
⅜	581·8864	⅜	699·8347	⅜	828·6601
½	585·4077	½	703·6959	½	832·8612
⅝	588·9395	⅝	707·5677	⅝	837·0729
¾	592·4820	¾	711·4501	¾	841·2952
⅞	596·0351	⅞	715·3431	⅞	845·5281
42 *in.*	599·5989	46 *in.*	719·2467	50 *in.*	849·7716
⅛	603·1732	⅛	723·1610		
¼	606·7582	¼	727·0859		
⅜	610·3538	⅜	731·0214		
½	613·9600	½	734·9675		
⅝	617·5769	⅝	738·9242		
¾	621·2043	¾	742·8916		
⅞	624·8424	⅞	746·8696		

The Editor of the preceding tables begs to state, that in consequence of the numerous errors having been found in former impressions of the five foregoing tables, it was thought necessary to recompute the whole afresh, which has all been carefully done; and it is presumed that in the present edition no errors of any consequence will be found, as the methods employed in the construction of the tables were such as nearly to preclude the possibility of error in the computations.

SAMUEL MAYNARD.

8, *Earl's Court, Leicester Square,*
London, September 3rd, 1852.

EXAMPLES TO TABLE V.

Ex. 1. Required the weight of a cylindrical column of water whose diameter is $47\frac{3}{8}$ *inches*, and length 1 *foot?*

Here, in *column* 1, *page* 58, will be found $47\frac{3}{8}$ *inches*, against which, in the next column, will be found 762·8878 *lbs.* avoirdupois, the weight required.

Note 1. When the length of the cylinder differs from 1 foot, multiply the tabular number by the length in feet.

Note 2. The weight of cylindrical columns of various substances may be found by means of this Table V., and the Table VI. of specific gravities, *page* 60, by multiplying the tabular number of Table V. by the length of the column in feet (when it differs from 1 foot), and by the specific gravity given in *page* 60, and dividing by 1000.

Ex. 2. Required the weight of a cylindrical column of cast iron, whose diameter is $7\frac{1}{8}$ inches, and length 115 *inches?*

Here 115 inches $= 9\frac{7}{12}$ feet, the length, and 7271 = the specific gravity of cast iron, by Table VI., *page* 60.

Then, by Table V., *page* 56, tabular No., for $7\frac{1}{8}$ *in.* = 17·2557 *lbs. av.*

9

155·3013

6 *in.* = $\frac{1}{2}$ 8·6278

1 *in.* = $\frac{1}{6}$ 1·4380

Weight of given volume of water = 165·3671 *lbs. av.*

Table VI. *page* 60, Specific gravity = 7271

1653671
11575697
3307342
11575697

1202384·1841 *lbs. av.*

which, divided by 1000, gives 1202·3842 *lbs. av.*, the weight of the cast iron column required.

Ex. 3. Required the weight of a cast iron cylindrical pipe $26\frac{1}{4}$ *inches*, outside diameter, and inside diameter $23\frac{3}{4}$ *in.*, the length being $6\frac{1}{2}$ *feet?*

lbs. av.

The tabular number for $26\frac{1}{4}$ = 234·2183

The tabular number for $23\frac{3}{4}$ = 191·7297

Difference = 42·4886

Then, (42·4886 *lbs. av.* × $6\frac{1}{2}$ × 7271) ÷ 1000 = 42·4886 *lbs. av.* × $6\frac{1}{2}$ × 7·271 = 2008·0750 *lbs. av.* = *Ans.*

TABLE VI.

COMBINING THE SPECIFIC GRAVITIES AND OTHER PROPERTIES OF BODIES. WATER THE STANDARD OF COMPARISON, OR 1000.

Names.	Specific gravity.	METALS. Melting points in degrees of Fahrenheit.	Contraction in parts of an *in.* per lineal *ft.* from the fluid to the average temperature in solid state.	Ultimate cohesive strength of an *inch sq.* prism in tons.	Scale of wire-drawing ductility.	Scale of laminable ductility.	Ratio of hardness.	Scale as conductors of electricity.	Ratio of power in the conduction of heat.
Platinum.....	21000	3280	...	...	3	5	...	...	3·8
Pure Gold	19258	2016	...	...	1	1	1·8	3	10·0
Mercury	13568	...	...	...	...	...	...	...	...
Lead	11344	594	·319	·81	8	7	1·0	6	1·8
Pure Silver.....	10474	1873	...	...	2	2	2·4	2	9·7
Bismuth	9880	476	·156	1·45	...	...	2·0	...	...
Copper, cast	8788	3587	·193	8·51	...	...	...	...	...
,, wrought	8915	...	...	15·08	5	3	2·8	1	8·9
Brass, cast	8396	3807	·210	8·01	...	...	to any degree	...	...
,, sheet.....	8544	...	...	12·23	6	6	...	...	8·6
Iron, cast	7271	3797	·125	7·87	...	...	to any degree	...	...
,, bar.....	7788	...	·137	25·00	4	8	4·7	4	3·7
Steel, soft	7833	...	·133	58·91	...	...	...	...	...
,, hard	7816	...	...	...	...	...	to any degree	...	...
Tin, cast.....	7292	442	·278	2·11	8	4	1 2	5	3 0
Zinc, cast.....	7190	700	·329	5·06	7	8	1·6	7	3·6

Names.	STONES, EARTHS, &c. Specific gravity.	Weight of a cubic foot in *lbs.*	Cubic feet in a ton.	Tons required to crush 1½ *inch* cubes.
Marble, average	2720	170·00	13¼	9·25
Granite, ditto...	2651	165·68	13½	6·2
Purbeck stone..	2601	162·56	13¾	9·0
Portland ditto...	2570	160·62	14	4·5
Bristol ditto	2554	159·62	14	...
Millstone.....	2484	155·25	14½	...
Paving stone ...	2416	150·93	14¾	5·7
Craigleith ditto	2362	147 62	15¼	5·0
Grindstone	2143	133·93	16¾	6·6
Chalk, Brit.....	2781	173·81	12¾	0·5
Brick	2000	125·00	18	0·8
Coal, Scotch	1300	81·15	27½	...
,, Newcastle	1270	79·37	28¼	...
,, Staffordsh.	1240	77·50	29	...
,, Cannel	1238	77·37	29	...

TABLE VII.

OF CIRCUMFERENCES, AREAS, SQUARES, AND CUBES OF FRACTIONAL NUMBERS.

TABLE VII.

OF CIRCUMFERENCES, AREAS, SQUARES, AND CUBES OF FRACTIONAL NUMBERS.

Area.	Circum.	Diam.	Square.	Cube.
·7854	3·1416	1 *in.*	1	1.
·9503	3·4557	·1	1·21	1·331
·9940	3·5343	·125	1·26	1·423
1·1309	3·7699	·2	1·44	1·728
1·2271	3·9270	·25	1·56	1·953
1·3273	4·0840	·3	1·69	2·197
1·4848	4·3197	·375	1·89	2·599
1·5393	4·3982	·4	1·96	2·744
1·7671	4·7124	·5	2·25	3·375
2·0106	5·0265	·6	2·56	4·096
2·0739	5·1051	·625	2·64	4·291
2·2698	5·3407	·7	2·89	4·913
2·4052	5·4978	·75	3·06	5·359
2·5446	5·6548	·8	3·24	5·832
2·7610	5·8905	·875	3·51	6·591
2·8352	5·9690	·9	3·61	6·859
3·1416	6·2832	2 *in.*	4	8
3·4636	6·5973	·1	4·41	9·261
3·5463	6·6759	·125	4·51	9·595
3·8013	6·9115	·2	4·84	10·648
3·9760	7·0686	·25	5·06	11·390
4·1547	7·2256	·3	5·29	12·167
4·4302	7·4613	·375	5·64	13·396
4·5239	7·5398	·4	5·76	13·824
4·9087	7·8540	·5	6·25	15·625
5·3093	8·1681	·6	6·76	17·576
5·4119	8·2467	·625	6·89	18·087
5·7255	8·4823	·7	7·29	19·683
5·9395	8·6394	·75	7·56	20·7968
6·1575	8·7964	·8	7·84	21·952
6·4918	9·0321	·875	8·26	23·7636
6·6052	9·1106	·9	8 41	24·389
7·0686	9·4248	3 *in.*	9	27
7·5476	9·7389	·1	9·61	29·791
7·6699	9·8175	·125	9·76	30·5175
8·0424	10·0531	·2	10·24	32·768
8·2957	10·2102	·25	10·56	34·328
8·5530	10·3672	·3	10·89	35·937
8·9462	10·6029	·375	11·39	38·443
9·0792	10·6814	·4	11·56	39·304
9·6211	10·9956	·5	12·25	42·875
10·1787	11·3097	·6	12·96	46·656
10·3206	11·3883	·625	13·14	47·634
10·7521	11·6239	·7	13·69	50·653
11·0446	11·7810	·75	14·06	52·734
11·3411	11·9380	·8	14·44	54·872

TABLE VII.

Area.	Circum.	Diam.	Square.	Cube.
11·7932	12·1737	3 ·875	15·10	58·185
11·9459	12·2522	·9	15·21	59·319
12·5664	12·5664	4 *in.*	16	64
13·2025	12·8805	·1	16·81	68·921
13·3640	12·9591	·125	17·01	70·189
13·8544	13·1947	·2	17·64	74·088
14·1862	13·3518	·25	18·06	76·765
14·5220	13·5088	·3	18·49	79·507
15·0331	13·7445	·375	19·14	83·740
15·2053	13·8230	·4	19·36	85·184
15·9043	14·1372	·5	20·25	91·125
16·6190	14·4513	·6	21·16	97·336
16·8001	14·5299	·625	21·39	98·931
17·3494	14·7655	·7	22·09	103·823
17·7205	14·9226	·75	22·56	107·171
18·0956	15·0796	·8	23·04	110·592
18·6655	15·3153	·875	23·76	115·857
18·8574	15·3938	·9	24·01	117·649
19·6350	15·7080	5 *in.*	25	125
20·4282	16·0221	·1	26·01	132·651
20·6290	16·1007	·125	26·26	134·611
21·2372	16·3363	·2	27·04	140·608
21·6475	16·4934	·25	27·56	144·703
22·0618	16·6504	·3	28·09	148·877
22·6907	16·8861	·375	28·89	155·287
22·9022	16·9646	·4	29·16	157·464
23·7583	17·2788	·5	30·25	166·375
24·6301	17·5929	·6	31·36	175·616
24·8515	17·6715	·625	31·64	177·978
25·5176	17·9071	·7	32·49	185·193
25·9672	18·0642	·75	33·06	190·109
26·4208	18·2212	·8	33·64	195·112
27·1085	18·4569	·875	34·51	202·779
27·3397	18·5354	·9	34·81	205·379
28·2744	18 8496	6 *in.*	36	216
29·2247	19·1637	·1	37·21	226·981
29·4647	19·2423	·125	37·51	229·783
30·1907	19·4779	·2	38·44	238·328
30·6796	19·6350	·25	39·06	244·140
31·1725	19·7920	·3	39·69	250·047
31·9192	20·0277	·375	40·64	259·083
32·1699	20·1062	·4	40·96	262·144
33·1831	20·4204	·5	42·25	274·625
34·2120	20·7345	·6	43·56	287·496
34·4717	20·8131	·625	43·89	290·775
35·2566	21·0487	·7	44·89	300·763
35·7847	21·2058	·75	45·56	307·546
36·3168	21·3628	·8	46·24	314·432
37·1224	21·5985	·875	47·26	324·951
37·3928	21·6770	·9	47·61	328·509

TABLE VII.

Area.	Circum.	Diam.	Square.	Cube.
38·4846	21·9912	7 *in.*	49	343
39·5920	22·3053	·1	50·41	357·911
39·8713	22·3839	·125	50·76	361·704
40·7151	22·6195	·2	51·84	373·248
41·2825	22·7766	·25	52·56	381·078
41·8539	22·9336	·3	53·29	389·017
42·7184	23·1693	·375	54·39	401·130
43·0089	23·2478	·4	54·76	405·224
44·1787	23·5620	·5	56·25	421·875
45·3647	23·8761	·6	57·76	438·976
45·6636	23·9547	·625	58·14	443·322
46·5663	24·1903	·7	59·29	456·533
47·1730	24·3474	·75	60·06	465·484
47·7837	24·5044	·8	60·84	474·552
48·7070	24·7401	·875	62·01	488·373
49·0168	24·8186	·9	62·41	493·039
50·2656	25·1328	8 *in.*	64	512
51·5300	25·4469	·1	65·61	531·441
51 8486	25·5255	·125	66·01	536·376
52·8102	25·7611	·2	67·24	55 368
53·4562	25·9182	·25	68·06	561·515
54·1062	26·1752	·3	68·89	571·787
55·0883	26·3109	·375	70·14	587·427
55·4178	26·3894	·4	70·56	592·704
56·7451	26·7036	·5	72·25	614·125
58·0881	27·0177	·6	73·96	636·056
58·4264	27·0963	·625	74·39	641·619
59·4469	27·3319	·7	75·69	658·503
60·1321	27·4890	·75	76·56	669·921
60·8213	27·3460	·8	77·44	681·472
61·8625	27·8817	·875	78·76	699·044
62·2115	27·9652	·9	79·21	704·969
63·6174	28·2744	9 *in.*	81	729
65·0389	28·5885	·1	82·81	753·571
65·3968	28·6671	·125	83·26	759·798
66·4762	28·9027	·2	84·64	778·688
67·2007	29·0598	·25	85·56	791·453
67·9292	29·2168	·3	86·49	804·357
69·0293	29·4525	·375	87·89	823·974
69·3979	29·5310	·4	88·36	830·584
70·8823	29·8452	·5	90·25	857·375
72·3824	30·1593	·6	92·16	884·736
72·7599	30·2379	·625	92·64	891·666
73·8982	30·4735	·7	94·09	912·673
74·6620	30·6306	·75	95·06	926·859
75·4298	30·7876	·8	96·04	941·192
76·5887	31·0233	·875	97·51	962·096
76·9770	31·1018	·9	98·01	970·299
78·5400	31·4160	10 *in.*	100	1000
80·1186	31·7301	·1	102·01	1030·301

TABLE VII.

Area.	Circum.	Diam.	Square.	Cube.
80·5157	31·8087	10·125	102·51	1037·970
81·7130	32·0443	·2	104·04	1061·208
82·5160	32·2014	·25	105·06	1076·890
83·2320	32·3580	·3	106·09	1092·727
84·5409	32·5941	·375	107·64	1116·771
84·9488	32·6726	·4	108·16	1124·864
86·5903	32·9868	·5	110·25	1157·625
88·2475	33·3009	·6	112·36	1191·016
88·6643	33·3795	·625	112·89	1199·462
89·9204	33·6150	·7	114·49	1225·043
90·7627	33·7722	·75	115·56	1242·296
91·6090	33·9292	·8	116·64	1259·712
92·8858	34·1649	·875	118·26	1286·138
93·3133	34·2434	·9	118·81	1295·029
95·0334	34·5576	11 *in.*	121	1331
96·7691	34·8717	·1	123·21	1367·631
97·2053	34·9503	·125	123·76	1376·892
98·5205	35·1859	·2	125·44	1404·928
99·4021	35·3430	·25	126·56	1423·828
100·2877	35·5011	·3	127·69	1442·897
101·6234	35·7357	·375	129·39	1471·818
102·0705	35·8142	·4	129·96	1481·044
103·8691	36·1284	·5	132·25	1520·875
105·6834	36·4425	·6	134·56	1560·896
106·1394	36·5211	·625	135·14	1571·009
107·5134	36·7567	·7	136·89	1601·613
108·4342	36·9138	·75	138·06	1622·234
109·3590	37·0708	·8	139·24	1643·032
110·7536	37·3065	·875	141·01	1674·560
111·2204	37·3840	·9	141·61	1685·159
113·0976	37·6992	12 *in.*	144	1728
114·9904	38·0133	·1	146·41	1771·561
115·4660	38·0919	·125	147·01	1782·564
116·8989	38·3275	·2	148·84	1815·848
117·8590	38·4846	·25	150·06	1838·265
118·8231	38·6416	·3	151·29	1860·867
120·2766	38·8773	·375	153·14	1895·115
120·7631	38·9558	·4	153·76	1906·624
122·7187	39·2700	·5	156·25	1953·125
124·6901	39·5841	·6	158·76	2000·376
125·1854	39·6627	·625	159·39	2012·306
126·6771	39·8983	·7	161·29	2048·383
127·6765	40·0554	·75	162·56	2072·671
128·6799	40·2124	·8	163·84	2097·152
130·1923	40·4481	·875	165·76	2134·232
130·6984	40·5266	·9	166·41	2146·689
132·7236	40·8408	13 *in.*	169	2197
134·7824	41·1549	·1	171·61	2248·191
135·2974	41·2338	·125	172·26	2260·986
136·8480	41·4691	·2	174·24	2299·968

TABLE VII.

Area.	Circum.	Diam.	Square.	Cube.
137·8867	41·6262	13·25	175·56	2326·203
138·9294	41·7832	·3	176·89	2352·637
140·5007	42·0189	·375	178·89	2392·661
141·0264	42·0974	·4	179·56	2406·104
143·1391	42·4116	·5	182·25	2460·375
145·2675	42·7257	·6	184·96	2515·456
145·8021	42·8043	·625	185·64	2529·353
147·4177	43·0399	·7	187·69	2571·353
148·4896	43·1970	·75	189·06	2599·609
149·5715	43·3540	·8	190·44	2628·072
151·2017	43·5897	·875	192·51	2671·154
151·7471	43·6682	·9	193·21	2685·619
153·9384	43·9824	14 *in.*	196	2744
156·1453	44·2965	·1	198·81	2803·221
156·6995	44·3751	·125	199·51	2818·157
158·3680	44·6107	·2	201·64	2863·288
159·4852	44·7676	·25	203·06	2893·640
160·6064	44·9248	·3	204·49	2924·207
162·2956	45·1605	·375	206·64	2970·458
162·8605	45·2390	·4	207·36	2985·984
165·1303	45·5532	·5	210·25	3048·625
167·4158	45·8673	·6	213·16	3112·136
167·8986	45·9459	·625	213·89	3128·150
169·7179	46·1815	·7	216·09	3176·523
170·8735	46·3386	·75	217·56	3209·046
172·0240	46·4656	·8	219·04	3241·792
173·7820	46·7313	·875	221·26	3291·325
174·3636	46·8098	·9	222·01	3307·949
176·7150	47·1240	15 *in.*	225	3375
179·0790	47·4381	·1	228·01	3442·951
179·6725	47·5167	·125	228·76	3460·079
181·4588	47·7523	·2	231·04	3511·808
182·6545	47·9094	·25	232·56	3546·578
183·8542	48·0664	·3	234·09	3581·577
185·6612	48·3021	·375	236·39	3633·505
186·2654	48·3806	·4	237·16	3652·264
188·6923	48·6948	·5	240·25	3723·875
191·1349	49·0089	·6	243·36	3796·416
191·7480	49·0875	·625	244·14	3814·690
193·5932	49·2321	·7	246·49	3869·893
194·8282	49·4802	·75	248·06	3906·984
196·0672	49 6372	·8	249·64	3944·312
197·9330	49·8729	·875	252·01	4000·747
198·5569	49·9514	·9	252·81	4019·679
201·0624	50·2656	16 *in.*	256	4096
203·5835	50·5797	·1	259·21	4173·281
204·2162	50·6583	·125	260·01	4192·751
206·1209	50·8939	·2	262·44	4251·528
207·3946	51·0510	·25	264·06	4291·015
208·6723	51·2080	·3	265·69	4330·747

TABLE VII.

Area.	Circum.	Diam.	Square.	Cube.
210·5976	51·4437	16·375	268·14	4390·802
211·1411	51·5224	·4	268·96	4410·944
213·8251	51·8364	·5	272·25	4492·125
216·4248	52·1505	·6	275·56	4574·296
217·0772	52·2291	·625	276·39	4594·993
219·0402	52·4647	·7	278·89	4657·463
220·3537	52·6218	·75	280·56	4699·421
221·6712	52·7788	·8	282·24	4741·632
223·6549	53·0145	·875	284·76	4805·419
224·3189	53·0930	·9	285·61	4826·809
226·9086	53·4072	17 *in.*	289	4913
229·6588	53·7213	·1	292·41	5000·211
230·3308	53·7999	·125	293·26	5122·173
232·3527	54·0355	·2	295·84	5088·448
233·7055	54·1926	·25	297·56	5132·953
235·0623	54·3496	·3	299·29	5177·717
237·1049	54·5853	·375	301·89	5245·349
237·7877	54·6038	·4	302·76	5268·024
240·5287	54·9780	·5	306·25	5359·375
243·2855	55·2921	·6	309·76	5451·776
243·9771	55·3707	·625	310·64	5475·040
246·0579	55·6063	·7	313·29	5545·233
247·4500	55·7634	·75	315·06	5592·359
248·8461	55·9204	·8	316·84	5639·752
250·9475	56 1561	·875	319·31	5711·341
251·6500	56·2346	·9	320·41	5735·339
254·4696	56·5488	18 *in.*	324	5832
257·3048	56·8629	·1	327·61	5929·741
258·0161	56·9415	·125	328·51	5954·345
260·1558	57·1770	·2	331·24	6028·568
261·5872	57·3342	·25	333·06	6078·390
263·0226	57·4912	·3	334·89	6128·487
265·1829	57·7269	·375	337·64	6204·146
265·9050	57·8054	·4	338·56	6229·504
268·8031	58·1196	·5	342·25	6331·625
271·7169	58·4337	·6	345·96	6434·856
272·4479	58·5123	·625	346·89	6460·837
274·6465	58·7479	·7	349·69	6539·203
276·1171	58·9056	·75	351·56	6591·796
277·5917	59·0620	·8	353·44	6644·672
279·8110	59·2977	·875	356·26	6724·513
280·5527	59·3762	·9	357·21	6751·269
283·5294	59·6904	19 *in.*	361	6859
286·5217	60·0045	·1	364·81	6967·871
287·2723	60·0831	·125	365·76	6995·263
289·5298	60·3187	·2	368·64	7077·888
291·0317	60·4758	·25	370·56	7132·328
292·5536	60·6328	·3	372·49	7189·057
294·8312	60·8685	·375	375·39	7273·192
295·5931	60·9470	·4	376·36	7301·384

TABLE VII.

Area.	Circum.	Diam.	Square.	Cube.
298·6483	61·2612	19·5	380·25	7414·875
301·7192	61·5753	·6	384·16	7529·536
302·4894	61·6539	·625	385·14	7558·384
304·8060	61·8895	·7	388·09	7645·373
306·3550	62·0466	·75	390·06	7703·734
307·9082	62·2036	·8	392·04	7762·392
310·2452	62·4393	·875	395·01	7850·935
311·0252	62·5178	·9	396·01	7880·599
314·1600	62·8320	20 *in.*	400	8000
317·3094	63·1461	·1	404·01	8120·601
318·0992	63·2247	·125	405·01	8150·939
320·4746	63·4603	·2	408·04	8242·408
322·0630	63·6174	·25	410·06	8303·765
323·6554	63·7744	·3	412·09	8365·427
326·0514	64·0101	·375	415·14	8458·489
326·8520	64·0886	·4	416·16	8489·664
330·0643	64·4028	·5	420·25	8615·125
333·2923	64·7161	·6	424·36	8741·816
334·1018	64·7955	·625	425·39	8773·681
336·3360	65·0311	·7	428·49	8869·743
338·1637	65·1882	·75	430·56	8934·171
339·7954	65·3452	·8	432·64	8998·912
342·2503	65·5809	·875	435·76	9196·607
343·0705	65·6594	·9	436·81	9129·329
346·3614	65·9736	21 *in.*	441	9261
349·6679	66·2870	·1	445·21	9393·931
350·4970	66·3663	·125	446·26	9427·360
352·9901	66·6012	·2	449·44	9528·128
354·6571	66·7590	·25	451·56	9595·703
356·3281	66·7916	·3	453·69	9663·597
358·8419	67·1517	·375	456·89	9766·036
359·6817	67·2930	·4	457·96	9800·344
363·0511	67·5444	·5	462·25	9938·375
366·4362	67·8585	·6	466·56	10077·696
367·2849	67·9371	·625	467·64	10112·72
369·8370	68·1727	·7	470·89	10218·313
371·5432	68·3298	·75	473·06	10289·11
373·2534	68·4868	·8	475·24	10360·232
375·8261	68·7225	·875	478·51	10467·52
376·6856	68·8010	·9	479·61	10503·459
380·1336	69·1152	22 *in.*	484	10648
383·5972	69·4293	·1	488·41	10793·861
384·4655	69·5079	·125	489·51	10830·537
387·0765	69·7435	·2	492·84	10941·048
388·8220	69·9006	·25	495·06	11015·142
390·5751	70·0576	·3	497·29	11089·567
393·2031	70·2933	·375	500·64	11201·834
394·0823	70·3718	·4	501·76	11239·424
397·6087	70·6860	·5	506·25	11390·625
401·0509	71·0401	·6	510·76	11543·176

TABLE VII.

Area.	Circum.	Diam.	Square.	Cube.
402·0388	71·0787	22·625	511·89	11581·526
404·7087	71·3143	·7	515·29	11697·083
406·4935	71·4714	·75	517·56	11774·548
408·2823	71·6284	·8	519·84	11852·352
410·9728	71·8641	·875	523·26	11969·704
411·8716	71·9426	·9	524·41	12008·989
415·4766	72·2568	23 *in.*	529	12167
419·0972	72·5709	·1	533·61	12326·391
420·0049	72·6495	·125	534·76	12366·458
422·7336	72·8851	·2	538·24	12487·168
424·5577	73·0422	·25	540·56	12568·072
426·3858	73·1992	·3	542·89	12649·337
429·1352	73·4349	·375	546·39	12771·885
430·0536	73·5134	·4	547·56	12812·904
433·7371	73 8276	·5	552·25	12977·875
437·4363	74·1417	·6	556·96	13144·256
438·3636	74·2203	·625	558·14	13185·986
441·1511	74·4559	7	561·69	13312·053
443·0146	74·6130	75	564·06	13396·482
444·8819	74·7680	·8	566·44	13481·272
447·6992	75·0057	·875	570·01	13609·124
448·6283	75 0882	·9	571·21	13651·919
452·3904	75·3984	24 *in.*	576	13824
456·1681	75·7125	·1	580·81	13997·541
457·1150	75·7911	·125	582·01	14041·126
459·9616	76·0267	·2	585·64	14172·488
461·8642	76·1838	·25	588·06	14260·515
463 7708	76·3408	·3	590·49	14343·907
466·6380	76·5765	·375	594·14	14482·177
467·5957	76·6528	·4	595·36	14526·784
471·4363	76·9692	·5	600·25	14706·125
475·2926	77·2833	·6	605·16	14886·936
476·2592	77·3619	·625	606·39	14932·368
479·1646	77·5975	·7	610·09	15069·223
481·1065	77·7546	·75	612·56	15160·921
483·0524	77·9116	·8	615·04	15252·992
485·9785	78·1473	·875	618·76	15391·794
486·6958	78·2258	·9	620·01	15438·247
490·8750	78·5400	25 *in.*	625	15625
494·8098	78·8541	·1	630·01	15813·251
495·7960	78 9327	·125	631·26	15860·548
498·7604	79·1683	·2	635·04	16003·008
500·7415	79·3254	·25	637·56	16098·453
502·7266	79·4824	·3	640·09	16191·277
505·7117	79·7181	·375	643·89	16338·323
506·7086	79·7966	·4	645·16	16387·064
510·7063	80·8180	·5	650·25	16581·375
514·7196	80·4249	·6	655·26	16777·216
515·7255	80·5035	·625	656·64	16826·415
518·7488	80·7391	·7	660·49	16974·593

TABLE VII.

Area.	Circum.	Diam.	Square.	Cube.
520·7692	80·8962	25·75	663·06	17073·859
522·7936	81·0532	·8	665·64	17173·512
525·5837	81·2889	·875	669·51	17323·716
526·8541	81·3674	·9	670·81	17373·979
530 9304	81·6816	26 *in.*	676	17576
535·0223	81·9976	·1	681·21	17779·581
536·0477	82·0743	·125	682·51	17830·720
539·1299	82·3099	·2	686·44	17984·728
541·1896	82·4670	·25	689·06	18087·890
543·2533	82·6240	·3	691·69	18191·447
546·3561	82·8597	·375	695·64	18347·520
547·3923	82·9382	·4	696·96	18399·744
551·5471	83·2524	·5	702·25	18609·625
555·7176	83·5665	·6	707·56	18821·096
556·7627	83·6451	·625	708·89	18874·212
559·9038	83·8807	·7	712·89	19034·163
562·0027	84·0378	·75	715·56	19141·296
564·1056	84·1948	·8	718·24	19248·832
567·2674	84·4305	·875	722·26	19410·888
568·3232	84·5090	·9	723·61	19465·109
572·5566	84·8232	27 *in.*	729	19683
576·8056	85·1373	·1	734·41	19902·511
577·8703	85·2159	·125	735·76	19957·642
581·0703	85·4515	·2	739·84	20123·648
583·2085	85 6086	·25	742·56	2023$_4$·828
585·3507	85·7656	·3	745·29	20346·417
588·5714	86·0013	·375	749·39	20514·567
589·6469	86·0798	·4	750·76	20570·824
593·9587	86·3940	·5	756·25	20796·875
598·2863	86·7081	·6	761·76	21024·576
599·3706	86·7687	·625	763·14	21081·759
602·6295	87·0223	·7	767·29	21253·933
604·0470	87·1794	·75	770·06	21369·234
606·9885	87·3364	·8	772·84	21484·952
610·2680	87·5721	·875	777·01	21659·309
611·3632	87·6506	·9	778·41	21717·639
615·7536	87·9648	28 *in.*	784	21952
620·1596	88·2789	·1	789·61	22188·041
621·2636	88·3575	·125	791·01	22427·313
624·5814	88·5931	·2	795·24	22425·768
626·7982	88·7502	·25	798·06	22545·265
629·0190	88·9072	·3	800·89	22665·187
632·3574	89·1429	·375	805·14	22845·864
633·4722	89·2214	·4	806·56	22906·304
637·9411	89·5316	·5	812·25	23149·125
642·4257	89·8497	·6	817·96	23393·656
643·3494	89·9283	·625	819·39	23455·056
646·9261	90·1639	·7	823·69	23639·903
649·1821	90·3210	·75	826·56	23763·671
651·4421	90·4780	·8	829·44	23887·872

TABLE VII.

Area.	Circum.	Diam.	Square.	Cube.
654·8395	90·7137	28·875	833·76	24074·981
655·9739	90·7922	·9	835·21	24137·569
660·5214	91·1064	29 *in.*	841	24389
665·0845	91·4205	·1	846·81	24642·171
666·2278	91·4991	·125	848·26	24705·735
669·6634	91·7347	·2	852·64	24897·088
671·9587	91·8918	·25	855·56	25025·203
674·2580	92·0488	·3	858·49	25153·757
677·7143	92·2845	·375	862·89	25347·411
678·8663	92·3630	·4	864·36	25412·184
683·4943	92·6772	·5	870·25	25672·375
688·1360	92·9913	·6	876·16	25934·336
689·2989	93·0699	·625	877·64	26000·102
692·7934	93·3055	·7	882·09	26198·073
695·1280	93·4626	·75	885·06	26330·609
697·4666	93·6196	·8	888·04	26463·592
700·9817	93·8553	·875	892·51	26663·903
702·1554	93·9338	·9	894·01	26730·899
706·8600	94·2480	30 *in.*	900	27000
711·5802	94·5621	·1	906·01	27270·901
712·7627	94·6407	·125	907·51	27338·907
716·3162	94·8763	·2	912·04	27543·608
718·6900	95·0334	·25	915·06	27689·640
721·0678	95·1904	·3	918·09	27818·127
724·6419	95·4261	·375	922·64	28028·208
725·8352	95 5046	·4	924·16	28094·464
730·6183	95·8188	·5	930·25	28372·625
735·4171	96·1329	·6	936·36	28652·616
736·6193	96·2115	·625	937·89	28722·899
740·2316	96·4471	·7	942·49	28934·443
742·6447	96·6042	·75	945·56	29076·046
745·0618	96 7612	·8	948·64	29218·112
748·6948	96·9969	·875	953·26	29432·075
749·9077	97·0754	·9	954·81	29503·629
754·7694	97·3896	31 *in.*	961	29791
759·6467	97·7037	·1	967·21	30080·231
760·8685	97·7823	·125	968·76	30152·829
764·5397	98·0179	·2	973·44	30371·328
766·9921	98·1750	·25	976·56	30517·578
769·4485	98·3320	·3	979·69	30664·297
773·1404	98·5677	·375	984·39	30885·255
774·3729	98·6452	·4	985·96	30959·144
779·3131	98·9604	·5	992·25	31255·875
784·2689	99·2745	·6	998·56	31554·496
785·5104	99·3531	·625	1000·140	31629·446
789·2406	99 5887	·7	1004·89	31855·013
791·7322	99·7458	·75	1008·06	32005·984
794·2278	99·9028	·8	1011·24	32157·432
797·9786	100·1385	·875	1016·01	32385·497
799·2308	100·2170	·9	1017·61	32461·759

TABLE VII.

Area.	Circum.	Diam.	Square.	Cube.
804·2496	100·5312	32 *in.*	1024	32768
809·2840	100·8453	·1	1030·41	33076·161
810·5450	100·9240	·125	1032·01	33153·501
814·3341	101·1595	·2	1036·84	33386·248
816·8650	101·3166	·25	1040·06	33542·015
819·3999	101·4736	·3	1043·29	33698·267
823·2096	101·7093	·375	1048·84	33956·314
824·4815	101·7478	·4	1049·76	34012·224
829·5787	102·1020	·5	1056·25	34328·125
834·6917	102·4161	·6	1062·76	34645·976
835·9724	102·4947	·625	1064·39	34725·743
839·8203	102·7303	·7	1069·59	34965·783
842·3905	102·8874	·75	1072 56	35026·421
844·9647	103·0444	·8	1075·84	35287·552
848·8333	103·2801	·875	1080·76	35530·169
850·9248	103·3586	·9	1082·41	35611·289
855·3006	103·6728	33 *in.*	1089	35937
860·4920	103·9869	·1	1095·61	36264·691
861·7904	104·0653	·125	1097·26	36346·923
865·6992	104·3011	·2	1102·24	36594·368
868·3068	104·4580	·25	1105·56	36759·953
870·9222	104·6151	·3	1108·89	36926·037
874·8477	104·8507	·375	1113·89	37176·099
876·1608	104·9294	·4	1115·56	37259·704
881·4151	105·2436	·5	1122·25	37595·375
886·6851	105·5577	·6	1128·96	37933·056
888·0030	105·6361	·625	1130·64	38071·791
891·9709	105·8719	·7	1135·69	38272·733
894·6176	106·0288	·75	1139·06	38443·359
897·2723	106·1860	·8	1142·44	38614·472
901·2567	106·4215	·875	1147·51	38872·091
902·5895	106·5002	·9	1149·21	38958·219
907·9224	106·8144	34 *in.*	1156	39304
913·2709	107·1285	·1	1162·81	39651·821
914·6084	107·2069	·125	1164·51	39739·095
918·6352	107·4272	·2	1169·64	40001·688
921·3211	107·5995	·25	1173·06	40177·390
924·0115	107·7568	·3	1176·49	40353·607
928·0584	107·9922	·375	1181·64	40618·896
929·4109	108·0710	·4	1183·36	40707·584
934·8223	108·3852	·5	1190·25	41063·625
940·2494	108·6993	·6	1197·16	41421·736
941·6066	108·7779	·625	1198·89	41511·587
945·6922	109·0352	·7	1204·09	41781·923
948·4174	109·1703	·75	1207·56	41962·796
951·1508	109·3076	·8	1211·04	42144·192
955·2529	109·5630	·875	1216·26	42417·263
956·6250	109·6418	·9	1218·01	42508·549
962·1150	109·9560	35 *in.*	1225	42875
967·6206	110·2701	·1	1232·01	43243·551

TABLE VII.

Area.	Circum.	Diam.	Square.	Cube.
968·9973	110·3484	35·125	1233·76	43336 017
973·1420	110·5843	·2	1239·04	43614·208
975·9063	110·7411	·25	1242·56	43800·328
978·6790	110·8984	·3	1246·09	43986·977
982·8400	111·1338	·375	1251·39	44267·943
984·2318	111·2126	·4	1253·16	44361·864
989·8003	111·5268	·5	1260·25	44738·875
995·3845	111·8409	·6	1267·36	45118·016
996·7807	111·9192	·625	1269·14	45123·134
1000 9843	112·1551	·7	1274·49	45499·293
1003·7879	112·3119	·75	1278·06	45690·734
1006·6000	112·4692	·8	1281·64	45882·712
1010·8197	112·7046	·875	1287·01	46171·685
1012·2313	112·7834	·9	1288·81	46268·279
1017·8784	113·0976	36 *in.*	1296	46656
1023·5411	113·4117	·1	1303·21	47045·831
1024·9592	113·4913	·125	1308·01	47252·063
1029·2195	113·7259	·2	1310·44	47437·928
1032·0646	113·8830	·25	1314·06	47634·765
1034·9131	114·0400	·3	1317·69	47832·147
1039·1946	114·2757	·375	1323·14	48129·239
1040·6235	114·3542	·4	1324·96	48228·544
1046·3491	114·6684	·5	1332·25	48627·125
1052·0904	114·9825	·6	1339·56	49027·896
1053·5281	115·0611	·625	1341·39	49128·130
1057·8474	115·2967	·7	1346·89	49430·863
1060·7317	115·4538	·75	1350·56	49633·171
1063·6200	115·6108	·8	1354·24	49836·032
1067·9599	115·8465	·875	1359·76	50141·356
1069·4084	115·9250	·9	1361·61	50243·409
1075·2126	116·2392	37 *in.*	1369	50653
1081·0324	116·5533	·1	1376·41	51064·811
1082·4898	116·6319	·125	1378·26	51168·110
1086 8679	116·8675	·2	1383·84	51478·848
1089·7915	117·0246	·25	1387·56	51686·703
1092·7191	117·1816	·3	1391·29	51895·117
1097·1179	117·4193	·375	1396·89	52208·786
1098·5862	117·4958	·4	1398·76	52313 624
1104·4687	117·8100	·5	1406·25	52734·375
1110·3671	118·1241	·6	1413·76	53157·376
1111·8441	118·2027	·625	1415·64	53263·427
1116·2811	118·4383	·7	1421·29	53582·633
1119·2440	118·5954	·75	1425·06	53796·109
1122·2109	118·7524	·8	1428·84	54010·152
1126·6685	118·9881	·875	1434·50	54332·278
1128·1564	119 0666	·9	1436·41	54439·939
1134·1176	119·3808	38 *in.*	1444	54872
1140·0926	119·6949	·1	1451·61	55306·341
1141·5919	119·7735	·125	1453·51	55415·282
1146·0870	120·0091	·2	1459·24	55742·968

TABLE VII.

Area.	Circum.	Diam.	Square.	Cube.
1149·0892	120·1662	38·25	1463·06	55962·140
1152·0954	120·3232	·3	1466·89	56181·887
1156·6119	120 5589	·375	1472·64	56512·583
1158·1194	120·6374	·4	1474·56	56623·104
1164·1591	120·9516	·5	1482·25	57066·625
1170·2145	121·2657	·6	1489·76	57512·456
1171·7309	121·3443	·625	1491·89	57624·274
1176·2857	121·5799	·7	1497·69	57960·603
1179·327[illegible]	121·7370	·75	1501·56	58185·546
1182·3725	121·8940	·8	1505·44	58411·072
1186·9480	122·1297	·875	1511·26	58751·450
1188·4651	122·2082	·9	1513·21	58863·869
1194·5394	122·5224	39 *in.*	1521	59319
1200·7273	122·8365	·1	1528·81	59776·471
1202·2633	122·9151	·125	1530·76	59891·204
1206·8770	123 1507	·2	1536·64	60236·288
1209·9577	123·3078	·25	1540·56	60466·078
1213·0424	123·4648	·3	1544·49	60698·457
1217·6768	123·7005	·375	1550·39	61046·629
1219·2243	123·7790	·4	1552·36	61162·984
1225·4203	124·0932	·5	1560·25	61629·875
1231·6328	124·4073	·6	1568·16	62099·136
1233·1884	124·4859	·625	1570·14	62216·822
1237·8610	124·7215	·7	1576·09	62570·773
1240·9810	124 8786	·75	1580·06	62807·484
1244·1210	125·0356	·8	1584·04	63044·792
1248·7982	125·2713	·875	1590·01	63401·872
1250·3646	125·3498	·9	1592·01	63521·199
1256·6400	125 6640	40 *in.*	1600	64000
1262·9310	125·9781	·1	1608·01	64481·201
1264·5062	126·0567	·125	1610·01	64601·875
1269·2388	126·2923	·2	1616·04	64964·608
1272·3970	126 4494	·25	1620·06	65207·515
1275·5602	126·6064	·3	1624·09	65450·827
1280·3124	126·8421	·375	1630·14	65816·926
1281·8984	126·9206	·4	1632·16	65939·264
1288·2523	127·2348	·5	1640·25	66430·125
1294·6219	127·5489	·6	1648·36	66923·416
1296·2168	127·6275	·625	1650·39	67047·110
1301·0071	127 8631	·7	1656·49	67419·143
1304·2057	128·0202	·75	1660·56	67667·925
1307·4082	128·1772	·8	1664·64	67917·312
1312·2193	128·4129	·875	1670·76	68292·539
1313·8249	128·4914	·9	1672·81	68417·929
1320·2574	128·8056	41 *in.*	1681	68921
1326·7055	129·1197	·1	1689·21	69426·531
1328·3200	129·1983	·125	1691·26	69553·297
1333·1693	129·4323	·2	1697·44	69934·528
1336·4071	129·5910	·25	1701·56	70189·453
1339 6489	129·7480	·3	1705·69	70444·997

TABLE VII.

Area.	Circum.	Diam.	Square.	Cube.
1344·5189	129·8939	41·375	1711·89	70829·473
1346·1441	130·0622	·4	1713·96	70957·944
1352·6551	130·3764	·5	1722·25	71473·375
1359·1818	130·6905	·6	1730·56	71991·296
1360·8159	130·7961	·625	1732·64	72121·164
1365·7242	131·0047	·7	1738·39	72511·713
1369 0012	131·1618	·75	1743·06	72772·859
1372·2822	131·3188	·8	1747·24	73034·632
1377·2111	131·5545	·875	1753·51	73428·465
1378·8560	131·6320	·9	1755·61	73560·059
1385·4456	131·9472	42 *in.*	1764	74088
1392·0508	132·2613	·1	1772·41	74618·461
1393·7045	132·3399	·125	1774·51	74751·469
1398·6717	132·5755	·2	1780·84	75151·448
1401·9880	132·7326	·25	1785·06	75418 890
1405·3083	132·8896	·3	1789·29	75686·967
1410·2961	133·1253	·375	1795·64	76090·270
1411·9607	133·2038	·4	1797·76	76225·024
1418·6287	133·5180	·5	1806·25	76765·625
1425·3125	133·8321	·6	1814·76	77308·776
1426·9859	133·9107	·625	1816·89	77444·961
1432 0119	134·1463	·7	1823·29	77854·483
1435·3675	134·4034	·75	1827·56	78128·296
1438·7271	134·4604	·8	1831·84	78402·752
1443·7738	134·6961	·875	1838·26	78815·637
1445·4580	134·7746	·9	1840·41	78958·589
1452·2046	135·0888	43 *in.*	1849	79507
1458·9668	135·4029	·1	1857·61	80062·991
1460·6599	135·4815	·125	1859·76	80202·391
1465·7448	135·7170	·2	1866·24	80621·568
1469·1397	135·8742	·25	1870·56	80901·828
1472·5385	136·0332	·3	1874·89	81182·737
1477·6342	136·2669	·375	1881·39	81605·317
1479·3480	136·3454	·4	1883·56	81746·504
1486·1731	136·6596	·5	1892·25	82313·875
1493·0139	136·9737	·6	1900·96	82881·856
1494·7266	137·0523	·625	1903·14	83024·508
1499·8705	137·2879	·7	1909·69	83453·453
1503·3046	137·4450	·75	1914·16	83740·234
1506·7427	137 6020	·8	1918·44	84027·672
1511·9072	137·8377	·875	1925·01	84460·059
1513·6287	137·9162	·9	1927·21	84604·519
1520·5344	138·2304	44 *in.*	1936	85184
1527·4537	138·5445	·1	1944·81	85766·121
1529·1860	138·6231	·125	1947·01	85912·063
1534·3888	138·8887	·2	1953·64	86350·888
1537·8622	139·0158	·25	1958·06	86644·265
1541·3396	139·1728	·3	1962·49	86938·307
1546·5530	139·4085	·375	1969·14	87380·614
1548·3061	139·4870	·4	1971·36	87528·384

TABLE VII.

Area.	Circum.	Diam.	Square.	Cube.
1555·2883	139·8012	44·5	1980·25	88121·125
1562·2862	140·1153	·6	1989·16	88716·536
1564·0382	140·1939	·625	1991·39	88865·805
1569·2998	140·4295	·7	1998·09	89314·623
1572·8125	140·5866	·75	2002·56	89614·652
1576·3292	140·7436	·8	2007·04	89915·392
1581·6115	140·9793	·875	2013·76	90367·731
1583·3742	141·0578	·9	2016·01	90518·849
1590·4350	141·3720	45 *in.*	2025	91125
1597·5114	141·6861	·1	2034·01	91723·851
1599·2830	141·7647	·125	2036·26	91886·485
1604·6036	142·0003	·2	2043·04	92345·408
1608·1555	142·1574	·25	2047·56	92652·203
1611·7114	142·3144	·3	2052·09	92959·677
1617·0427	142·5501	·375	2058·89	93422·161
1618·8350	142·6286	·4	2061·16	93576·664
1625·9743	142·9428	·5	2070·25	94196·375
1633·1293	143·2569	·6	2079·36	94818·818
1634·9205	143·3355	·625	2081·64	94974·852
1640·3020	143·5711	·7	2088·49	95443·993
1643·8912	143·7282	·75	2093·06	95757·609
1647·4864	143·8852	·8	2097·64	96071·912
1652·8865	144·1209	·875	2104·515	96544·653
1654·6885	144·1994	·9	2106·81	96702·579
1661·9064	144·5136	46 *in.*	2116	97336
1669·1399	144·8277	·1	2125·21	97972·981
1670·9507	144·9063	·125	2127·51	98131·657
1676·3891	145·1419	·2	2134·44	98611·128
1680·0196	145·2990	·25	2139·06	98931·640
1683·6541	145·4560	·3	2143·69	99252·847
1689·1031	145·6917	·375	2150·64	99735·957
1690·9347	145·7702	·4	2152·96	99897·344
1698·2311	146·0844	·5	2162·25	100544·625
1705·5432	146·3985	·6	2171·56	101194·696
1707·3732	146·4771	·625	2171·89	101357·649
1712·8710	146·7127	·7	2180·89	101847·563
1716·5407	146·8698	·75	2185·56	102175·046
1720·2144	147·0268	·8	2190·24	102503·232
1725·7324	147·2625	·875	2197·26	102996·825
1727·5736	147·3410	·9	2199·61	103161·705
1734·9486	147·6552	47 *in.*	2209	103823
1742·3392	147·9693	·1	2218·41	104487·111
1744·1893	148·0479	·125	2220·76	104653·579
1749·7455	148·2835	·2	2227·84	105154·048
1753·4545	148·4406	·25	2232·56	105488·578
1757·1675	148·5976	·3	2237·29	105823·817
1762·7344	148·8333	·375	2244·39	106328·004
1764·6045	148·9118	·4	2246·76	106496·424
1772·0587	149·2260	·5	2256·25	107171·875
1779·5279	149·5361	·6	2265·76	107850·176

TABLE VII.

Area.	Circum.	Diam.	Square.	Cube.
1781·3976	149·6107	47·625	2268·14	108020·196
1787·0127	149·8543	·7	2275·29	108531·333
1790·7610	150·0114	·75	2280·06	108872·984
1794·5133	150·1684	·8	2284·84	109215·352
1800·1491	150·4041	·875	2292·01	109730·246
1802·0296	150·4826	·9	2294·41	109902·239
1809·5616	150·7968	48 *in.*	2304	110592
1817·1092	151·1109	·1	2313·61	111284·641
1818·9986	151·1895	·125	2316·01	111458·250
1824·6726	151·4251	·2	2323·24	111980·168
1828·4602	151·5822	·25	2328·06	112329·015
1832·2518	151·7392	·3	2332·29	112678·587
1837·9364	151·9749	·375	2340·14	113204·301
1839·8466	152·0534	·4	2342·56	113379·904
1847·4571	152·3676	·5	2352·25	114084·125
1855·0833	152·6817	·6	2361·96	114791·256
1856·9924	152·7603	·625	2364·39	114968·493
1862·7253	152·9959	·7	2371·69	115501·303
1868·5521	153·1530	·75	2376·56	115857·421
1870·3829	153·3100	·8	2381·44	116214·272
1876·1365	153·5457	·875	2388·76	116750·918
1878·0563	153·6242	·9	2391·21	116930·169
1885·7454	153·9384	49 *in.*	2401	117649
1893·4501	154·2525	·1	2410·81	118370·771
1895·3788	154·3311	·125	2413·26	118551·672
1901·1706	154·5667	·2	2420·64	119095·488
1905·0367	154·7238	·25	2425·56	119458·953
1908·9068	154·8808	·3	2430·49	119823·157
1914·7093	155·1165	·375	2437·89	120370·548
1916·6587	155·1950	·4	2440·36	120553·784
1924·4263	155·5092	·5	2450·29	121287·375
1932·2096	155·8233	·6	2460·16	122023·936
1934·1579	155·9019	·625	2462·64	122208·539
1940·0086	156·1375	·7	2470·09	122763·473
1943·9140	156·2946	·75	2475·06	123134·359
1947·8234	156·4516	·8	2480·04	123505·992
1953·6947	156·6873	·875	2487·51	124064·336
1955·6538	156·7558	·9	2490·01	124251·499
1963·5000	157·0800	50 *in.*	2500	125000
1971·3618	157·3941	·1	2510·01	125751·501
1973·3297	157·4727	·125	2512·51	125937·844
1979·2394	157·7083	·2	2520·04	126506·008
1983·1840	157·8654	·25	2525·06	126884·390
1987·1326	158·0224	·3	2530·09	127263·527
1993·0529	158·2581	·375	2537·64	127833·645
1995·0416	158·3366	·4	2540·16	128024·064
2002·9663	158·6508	·5	2550·25	127878 625
2010·9067	158·9649	·6	2561·36	129554·216
2012·8943	159·0435	·625	2562·89	129746·336
2018·8628	159·2791	·7	2570·49	130323·843

TABLE VII.

Area.	Circum.	Diam.	Square.	Cube.
2022·8467	159·4362	50·75	2575·56	130709·797
2026·8346	159·5932	·8	2580·64	131096·512
2032·8238	159·8289	·875	2588·26	131678·012
2034 8770	159·9072	·9	2590·81	131872·229
2042·8254	160·2216	51 *in.*	2601	132651
2050·8443	160·5357	·1	2611·21	133432·831
2052·8515	160·6143	·125	2613·76	133628·766
2058·8784	160·8499	·2	2621·44	134217·728
2062·9021	161·0070	·25	2626·56	134611·328
2066·9293	161·1640	·3	2631·69	135005·697
2072·9674	161·3997	·375	2639·39	135598·692
2074·9953	161·4782	·4	2641·96	135796·744
2083·0771	161·7924	·5	2652·25	136590·875
2091·1746	162·1065	·6	2662·56	137388·096
2093·2014	162·1851	·625	2665·14	137587·883
2099·2878	162·4207	·7	2672·89	138188·413
2103·3502	162·5778	·75	2678·06	138589·734
2107·4166	162·7340	·8	2683·24	138991·832
2113·5236	162·9705	·875	2691·01	139956·434
2115·5612	163·0490	·9	2693·61	139798·359
2123·7216	163·3632	52 *in.*	2704	140608
2131·8976	163·6773	·1	2714·41	141420·761
2133·9440	163·7559	·125	2717·07	141624·438
2140·0893	163·9953	·2	2724·84	142236·648
2144·1910	164·1486	·25	2730·06	142645·765
2148·2967	164·3056	·3	2735·29	143055·667
2154·4626	164·5413	·375	2743·14	143671·589
2156·5199	164·6198	·4	2745·76	143877·824
2164·7587	164·9340	·5	2756·25	144703·125
2173·0133	165·2481	·6	2766·76	145531·576
2175·0794	165·3267	·625	2769·39	145739·180
2181·2835	165·5623	·7	2777·29	146363·183
2185·4245	165·7194	·75	2782·56	146780·172
2189·5695	165·8764	·8	2787·84	147197·952
2195·7943	166·1121	·875	2795·76	147826·106
2197·8712	166·1906	·9	2798·41	148035·889
2206·1886	166·5048	53 *in.*	2809	148877
2214·5216	166·8189	·1	2819·61	149721·291
2216·6074	166·8975	·125	2822·26	149932·860
2222·8704	167·1330	·2	2830·24	150568·768
2227 0507	167·2902	·25	2835·56	150993·703
2231·2350	167·4472	·3	2940·89	151419·437
2237·5107	167·6829	·375	2848·89	152059·535
2239·6152	167·7614	·4	2851·56	152273·304
2248·0111	168·1756	·5	2862·25	153130·375
2256·4227	168·3894	·6	2872·96	153990·656
2258·5281	168·4683	·625	2875·64	154206·227
2264·8701	168·7049	·7	2883·69	154854·153
2269·0696	168·8610	·75	2889·06	155287·109
2273·2931	169·0180	·8	2894·44	155720·872

TABLE VII.

Area.	Circum.	Diam.	Square.	Cube.
2279·6357	169·2537	53·875	2902·51	156373·028
2281·7519	169·3322	·9	2905·21	156590·819
2290·2264	169 6464	54 *in.*	2916	157464
2298·7165	169·9605	·1	2926·81	158340·421
2300·8415	170·0391	·125	2929·51	158560·032
2307·2224	170·2747	·2	2937·64	159220·088
2311·4812	170·4318	·25	2943·06	159661·140
2315·7440	170·5888	·3	2948·49	160103·007
2322·1455	170·8245	·375	2956·64	160767·332
2324·2813	170·9030	·4	2959·36	160989·184
2332·8343	171·2172	·5	2970·25	161878·625
2341·4030	171·5313	·6	2981·16	162771·336
2343·5477	171·6099	·625	2983·89	162995·024
2349·9874	171·8455	·7	2992·09	163667·323
2354·2855	172·0026	·75	2997·56	164116·547
2358·5876	172·1596	·8	3003·04	164566·592
2365·0480	172·3953	·875	3011·26	165243·199
2367·2034	172·4738	·9	3014·01	165469·149
2375·8350	172·7880	55 *in.*	3025	166375
2384·4822	173·1021	·1	3036·01	167284·151
2386·6465	173·1807	·125	3038·76	167511·953
2393·1452	173·4163	·2	3047·04	168196·608
2397·4825	173·5734	·25	3052·56	168654·078
2401·8238	173·7304	·3	3058·09	169112·377
2403·3432	173·9661	·375	3066·39	169801·379
2410·5512	174·0446	·4	3069·16	170031·464
2419·2283	174·3588	·5	3080·25	170953·875
2427·9541	174·6729	·6	3091·36	171879·616
2430·1830	174·7515	·625	3094·14	172111·570
2436·6956	174·9771	·7	3102·49	172808·693
2441·0722	175·1442	·75	3108·06	173274·484
2445·4528	175·3092	·8	3113·64	173741·112
2452·0310	175·5369	·875	3122·01	174442·621
2454·2257	175·6154	·9	3124·81	174676·879
2463·0144	175·9296	56 *in.*	3136	175616
2471·8187	176·2437	·1	3147·21	176558·481
2474·0222	176·3223	·125	3150·01	176794·625
2480 6387	176·5579	·2	3158·44	177504·328
2485·0546	176·7150	·25	3164·06	177978·515
2489·4745	176·8720	·3	3169·69	178453·547
2496·1116	177·1077	·375	3178·14	179167·676
2498·3259	177·1862	·4	3180·96	179406·144
2507·1931	177·5004	·5	3192·25	180362·125
2516·0760	177·8145	·6	3203·56	181321·496
2518·2992	177·8931	·625	3206·39	181561·867
2524·9736	178·1287	·7	3214·89	182284·263
2529·4297	178·2858	·75	3220 56	182766·921
2533·8888	178·4428	·8	3226·24	183250·432
2540·5849	178·6785	·875	3234·76	183977·293
2542·8188	178·7570	·9	3237·61	184220·009

TABLE VII.

Area.	Circum.	Diam.	Square.	Cube.
2551·7646	179·0712	57 *in.*	3249	185193
2560·7260	179·3853	·1	3260·41	186169·411
2562·9688	179·4639	·125	3263·26	186414·048
2569·7031	179·6995	·2	3271·84	187149·411
2574·1975	179·8566	·25	3277·56	187640·453
2578·6959	180·0136	·3	3283·49	188149·240
2585·4509	180·2493	·375	3291·89	188872·223
2587·7045	180·3278	·4	3294·76	188132·517
2596·7287	180·6420	·5	3306·25	189119·224
2605·7687	180·9561	·6	3317·76	190109·375
2608·0311	181·0347	·625	3320·64	191351·914
2614·8243	181·2803	·7	3329·29	191102·976
2619·3580	181·4274	·75	3335·06	192599·859
2623·8957	181·5844	·8	3340·24	192100·033
2630·7095	181·8201	·875	3349·51	193853·215
2632·9828	181·8986	·9	3352·41	193100·539
2642·0856	182·2128	58 *in.*	3364	195112
2651·2046	182·5269	·1	3375·61	196122·941
2653·4861	182·6055	·125	3378·51	196376·219
2660·3382	182·8411	·2	3387·24	197137·368
2664·9112	182·9982	·25	3393·06	197645·890
2669·4882	183·1552	·3	3398·89	198155·287
2676·3609	183·3909	·375	3407·64	198921·020
2678·6538	183·4694	·4	3410·56	199176·704
2687·8351	183·7836	·5	3422·25	200201·625
2697 0321	184·0977	·6	3433·96	201230·056
2699·3338	184·1763	·625	3436·89	201487·711
2706·2449	184·4119	·7	3445·69	202262·003
2710·8571	184·5690	·75	3451·56	202779·296
2715·4733	184·7260	·8	3457·44	203297·472
2722·4050	184·9617	·875	3466·26	204076·387
2724·7175	185·0402	·9	3469·21	204336·469
2733·9774	185·3544	59 *in.*	3481	205379
2743·2529	185·6685	·1	3492·81	206425·071
2745·5743	185·4741	·125	3495·76	206687·141
2752·5442	185·9827	·2	3504·64	207472·688
2757·1957	186·1398	·25	3510·56	208000·828
2761·8512	186·2696	·3	3516·49	208527·857
2768·8418	186·5325	·375	3525·39	209320·066
2771·1739	186·6110	·4	3528·36	209584·584
2780·5123	186·9252	·5	3540·25	210644·875
2789·8661	187·2393	·6	3552·16	211708·736
2792·2074	187·3179	·625	3555·14	212975·258
2799·2362	187·5535	·7	3564·09	212776·173
2803·9270	187·7106	·75	3570·06	213311·234
2808·6218	187·8676	·8	3576·04	213847·192
2815·6712	188·1033	·875	3585·01	214642·809
2818·0230	188·1818	·9	3588·01	214921·799
2827·4400	188·4960	60 *in.*	3600	216000
2836·8726	188·8100	·1	3612·01	217081·801

TABLE VII.

Area.	Circum.	Diam.	Square.	Cube.
2839·2332	188·8887	60·125	3615·01	217352·813
2846·3210	189·1243	·2	3624·04	218167·208
2851·0510	189·2814	·25	3630·62	218711·265
2855·7850	189·4384	·3	3636·09	219256·227
2862·8934	189·6741	·375	3645·14	220075·363
2865·2648	189·7526	·4	3648·16	220348·864
2874·7603	190·0668	·5	3660·25	221445·125
2884·2615	190·3809	·6	3672·36	222454·016
2886 6517	190·4595	·625	3675·39	222820·555
2893·7984	190·6951	·7	3684·49	223668·543
2898·5677	190·8522	·75	3690·56	224201·672
2903·3410	191·0092	·8	3696·64	224755·712
2910·5083	191·2449	·875	3705·76	225588·481
2912·8993	191·3234	·9	3708·81	225866·529
2922·4734	191·6376	61 *in.*	3721	226981
2932·0631	191·9517	·1	3733·21	228099·131
2934·4630	192·0303	·125	3736·26	228379·235
2941·6685	192·2659	·2	3745·44	229220·928
2946·4771	192·4230	·25	3751·56	229783·203
2957·2897	192·5800	·3	3757·69	230346·397
2958·5159	192·8157	·375	3766·89	231192·911
2960·9265	192·8942	·4	3769·96	231475·544
2970·5790	193·2084	·5	3782·25	232608·375
2980·2474	193·5225	·6	3794·56	233744·896
2982·6669	193·6011	·625	3797·64	234029·602
2989·9314	193·8367	·7	3806·89	234885·113
2994·7792	193·9938	·75	3813·06	235456·609
2999·6300	194·0508	·8	3819·24	236029·032
3006·9161	194·3865	·875	3828·51	236659·403
3009·3464	194·4650	·9	3831·61	237176·659
3019·1776	194·7792	62 *in.*	3844	238328
3028·8244	195·0533	·1	3856·41	239483·061
3031·2635	195·1719	·125	3859·51	239772·406
3038·5809	195·4075	·2	3868·84	240641·848
3043·4740	195·5646	·25	3875·06	241222·640
3048·3651	195·7216	·3	3881·29	241804·367
3055·7091	195·9573	·375	3890·64	242678·707
3058·1591	196·0358	·4	3893·76	242970·624
3067·9687	196·3500	·5	3906·25	244140·625
3077·7941	196·6641	·6	3918·76	245314·676
3080·2529	196·7427	·625	3921·89	245608·399
3087·6341	196·9783	·7	3931·29	246491·883
3092 5615	197·1354	·75	3937·56	247082·047
3097·4919	197·2924	·8	3943·84	247673·152
3104·8948	197·5281	·875	3953·26	248561·574
3107·3644	197·6066	·9	3956·41	248858·189
3117·2526	197·9208	63 *in.*	3969	250047
3127·1564	198·2349	·1	3981·61	251239·591
3129·6349	198·3135	·125	3984·76	251538·328
3137·0758	198·5491	·2	3994·24	252435·968

TABLE VII.

Area.	Circum.	Diam.	Square.	Cube.
3142·0417	198·7062	63·25	4000·56	253035·578
3147·0114	198·7632	·3	4006·89	253638·137
3154·4732	199·0989	·375	4016·39	254538·754
3156·9664	199·1774	·4	4019·56	254840·104
3166·9291	199·4916	·5	4032·25	256047·875
3176·9115	199·8057	·6	4044·96	257259·456
3179·4096	199·8843	·625	4048·14	257562·945
3186·9097	200·1199	·7	4057·69	258474·853
3191·9146	200·2970	·75	4064·06	259083·984
3196·9235	200·4340	·8	4070·44	259694·072
3204·4442	200·6697	·875	4080·01	260610·996
3206·9531	200·7482	·9	4083 21	260917·119
3216·9984	201·0624	64 *in.*	4096	262144
3227·0593	201·3765	·1 .	4108·81	263374·721
3229·5770	201·4551	·125	4112·01	263683·000
3237·1360	201·6907	·2	4121·64	264609·288
3242·1782	201·8478	·25	4128·06	265228·015
3247·2284	202·0048	·3	4134·49	265847·707
3254·8080	202·2405	·375	4144·14	266779·051
3257·3365	202·3190	·4	4147·36	267089·984
3267·4603	202·6322	·5	4160·25	268336·125
3277·5998	202·9473	·6	4173·16	269586·136
3280·1372	203·0259	·625	4176·39	269899·242
3287·7550	203·2615	·7	4186·09	270840·023
3292·8385	203·4186	·75	4192·56	271468·422
3297·9260	203·5756	·8	4199·04	272097·792
3305·5645	203·8113	·875	4208·76	273043·668
3308·1126	203·8898	·9	4212·01	273359·449
3318·3150	204·2040	65 *in.*	4225	274625
3328·5340	204·5181	·1	4238·01	275894·451
3331·0900	204·5917	·125	4241·26	276212·422
3338·7668	204·8323	·2	4251·04	277165·808
3343·8875	204·9894	·25	4257·56	277805·953
3349·0162	205·1464	·3	4264·09	278445·077
3356·7137	205·3821	·375	4273·89	279405·608
3359·2814	205·4606	·4	4277·16	279726·264
3369·5623	205·7748	·5	4290·25	281011·375
3379·8589	206·0889	·6	4303·36	282300·416
3382·4355	206·1675	·625	4306·64	282623·289
3390·1712	206·4031	·7	4316·49	283593·393
3395·3332	206·5602	·75	4323·06	284241·359
3400·4992	206·7172	·8	4329·64	284890·312
3408·2555	206·9529	·875	4339·41	285865·590
3410·8429	207·0314	·9	4342·81	286191·179
3421·2024	207·3436	66 *in.*	4356	287496
3431·5775	207·6597	·1	4369·21	288804·781
3434·1737	207·7383	·125	4372·51	289132·594
3441·9633	207·9739	·2	4382·44	290117·528
3447·1676	208·1310	·25	4389·06	290775·390
3452·3749	208·2880	·3	4395·69	291434·247

TABLE VII.

Area.	Circum.	Diam.	Square.	Cube.
3460·1901	208 5237	66·375	4405·64	292424·395
3462·7971	208·6022	·4	4408·96	292754·944
3473·2351	208·9164	·5	4422·25	294079·625
3483·6888	209·2305	·6	4435·56	295408·296
3486·3047	209·3091	·625	4438·09	295741·086
3494·1640	209·5447	·7	4448·89	296740·936
3499·3987	209·7018	·75	4455·56	297408·797
3504·6432	209·8588	·8	4462·24	298077·632
3512·5174	210·0945	·875	4472·26	299082·762
3515·1430	210·1730	·9	4475·61	299418·309
3525·6606	210·4872	67 *in.*	4489	300763
3536·5928	210·8013	·1	4502·41	302111·711
3538·8283	210·8799	·125	4505·76	302449·516
3546·7407	211·1155	·2	4515·84	303464·448
3552·0185	211·2726	·25	4522·56	304142·328
3557·3043	211·4296	·3	4529·29	304821·217
3565·2374	211·6653	·375	4539·39	305841·442
3567·8837	211·7438	·4	4542·76	306182·024
3578·4787	212·0580	·5	4556·25	307546·875
3589·0895	212·3720	·6	4569·76	308915·776
3591·7446	212·5407	·625	4573·14	309258·633
3599·7159	212·6863	·7	4583·29	310288·733
3605·0350	212·8434	·75	4590·06	310976·734
3610·3581	213·0004	·8	4596·84	311665·752
3618·3500	213·2361	·875	4607·01	312701·184
3621·0160	213·3146	·9	4610·41	313046·839
3631·6896	213·6288	68 *in.*	4624	314432
3642·3788	213·9429	·1	4637·61	315821·241
3645·0536	214·0215	·125	4641·01	316169·187
3653·0838	214·2571	·2	4651·24	317214·568
3658·4402	214·4120	·25	4658·06	317912·766
3663·8040	214·5712	·3	4664·89	318611·987
3671·8554	214·8069	·375	4675·14	319662·738
3674·5410	214·8854	·4	4678·56	320013·504
3685·2931	215·1996	·5	4692·25	321419·129
3696·0060	215·5137	·6	4705·96	322828·856
3698·7554	215·5923	·625	4709·39	323181·930
3706·8485	215·8279	·7	4719·69	324242·703
3712·2421	215·9850	·75	4726·56	324951·472
3717·6437	216·1420	·8	4733·44	325660·672
3725 7535	216·3777	·875	4743·765	326726·977
3728·4587	216·4562	·9	4747·21	327082·769
3739·2894	216·7704	69 *in.*	4761	328509
3750·1357	217·0844	·1	4774·81	329939·371
3752·8498	217·1631	·125	4778·26	330297·609
3760·9978	217·3987	·2	4788·64	331373·888
3766·4327	217·5558	·25	4795·56	332092·703
3771·8756	217·7128	·3	4802·40	332812·557
3780·1443	217·9485	·375	4812·89	333894·285
3782·7691	218·0270	·4	4816·36	334255·384

TABLE VII.

Area.	Circum.	Diam.	Square.	Cube.
3793·6783	218·3412	69·5	4830·25	335702·375
3804·6032	218·6553	·6	4844·16	337153·536
3807·3369	218·7339	·625	4847·64	337516·977
3815·5438	218·9695	·7	4858·09	338608·873
3821·0200	219·1266	·75	4865·06	339338·109
3826·5002	219·2836	·8	4872·04	340068·392
3834·7277	219 5193	·875	4882·51	341165·778
3837·4722	219·5978	·9	4886·01	341532·099
3848·4600	219·9120	70 *in.*	4900	343000
3859·4952	220·2261	·1	4914·01	344472·101
3862·2167	220·3047	·125	4917·51	344840·781
3870·4826	220·5403	·2	4920·84	345948·408
3875·9960	220·6974	·25	4935·06	346688·141
3881·5174	220·8544	·3	4942·09	347428·927
3889·8039	221·0901	·375	4952·64	348542·082
3892·5680	221·1686	·4	4956·16	348913·664
3903·6343	221·4828	·5	4970·25	350402·625
3914·7163	221·7969	·6	4984·36	351895·816
3917·4893	221·8755	·625	4987·89	352259·774
3925·8140	222·1111	·7	4998·49	353393·243
3931·3687	222·2682	·75	5005·56	354413·547
3936·9274	222·4252	·8	5012·64	354894·912
3945·2728	222·6609	·875	5023 26	356023·949
3948·0565	222·7394	·9	5026·81	356400·829
3959·2014	223·0536	71 *in.*	5041	357911
3970·3619	223·3677	·1	5055·21	359425·431
3973·1545	223·4463	·125	5058·76	359804·703
3981·5381	223·6819	·2	5069·44	360944·128
3987·1301	223·8390	·25	5076·56	361705·078
3992·7301	223·9960	·3	5083·69	362467·097
4001·1344	224·2317	·375	5094·39	363612·129
4003·9373	224·3102	·4	5097·96	363994·344
4015·1611	224·6244	·5	5112·25	365525·875
4026·4002	224·9385	·6	5126·56	367061·696
4029·2124	225·0171	·625	5130·14	367446·320
4037·6550	225·2527	·7	5140·89	368601·813
4043·2882	225·4098	·75	5148·06	369373·484
4048·9294	225·5668	·8	5155·24	370146·232
4057·3886	225·8025	·875	5166·01	371307·371
4060·2116	225·8810	·9	5169·61	371694·959
4071·5136	226·1952	72 *in.*	5184	373248
4082·8332	226·5093	·1	5198·41	374805·361
4085·6631	226·5879	·125	5202·01	375195·375
4094·1645	226·8235	·2	5212·84	376367·048
4099·8350	226·9806	·25	5220·06	377149·515
4105·5125	227·1376	·3	5227·29	377933·067
4114·0356	227·3733	·375	5238·14	379110·425
4116·8793	227·4518	·4	5241·76	379503·424
4128·2587	227·7660	·5	5256·25	381078·125
4139·6524	228·0801	·6	5270·76	382657·976

TABLE VII.

Area.	Circum.	Diam.	Square.	Cube.
4142·5064	228·1587	72·625	5274·39	383052·617
4151·0667	228·3943	·7	5285·29	384240·583
4156·7785	228·5514	·75	5292·56	385033·921
4162·4943	228·7084	·8	5299·84	385828·352
4171·0753	228·9441	·875	5310·76	387022·043
4173·9376	229·0226	·9	5314·41	387420·489
4185·3966	229·3368	73 *in.*	5329	389017
4196·8712	229·6509	·1	5343·61	390617·891
4199·7424	229·7295	·125	5347·26	391018·797
4208·3614	229·9651	·2	5358·24	392223·168
4214·1107	230·1222	·25	5365·56	393027·453
4219·8678	230·2792	·3	5372·89	393832·837
4228·5077	230·5149	·375	5383·89	395042·972
4231·3896	230·5934	·4	5387·56	395446·904
4242·9271	230·9076	·5	5402·25	397065·375
4254·4803	231·2217	·6	5416·96	398688·256
4257·3711	231·3003	·625	5420·64	399094·664
4266·0493	231·5359	·7	5431·69	400315·553
4271·8396	231·6930	·75	5439·06	401130·359
4277·6399	231·8500	·8	5446·44	401947·272
4286·3327	232·0857	·875	5457·51	403173·964
4289·2343	232·1642	·9	5461·21	403583·419
4300·8504	232·4784	74 *in.*	5476	405224
4312·4821	232·7925	·1	5490·81	406869·021
4315·3926	232·8711	·125	5494·51	407280·968
4324·1296	233·1067	·2	5505·64	408518·488
4329·9572	233·2638	·25	5513·06	409344·890
4335·7928	233·4208	·3	5520·49	410172·407
4344·5505	233·6565	·375	5531·64	411415·769
4347·4717	233·7350	·4	5535·36	411830·784
4359·1663	234·0492	·5	5550·25	413493·625
4370·8766	234·3633	·6	5565·16	415160·936
4373·8067	234·4419	·625	5568·89	415578·461
4382·6026	234·6775	·7	5580·05	416832·723
4388·4715	234·8346	·75	5587·56	417670·296
4394·3448	234·9916	·8	5595·04	418508·992
4403·1610	235·2273	·875	5606·26	419769·136
4406·1018	235·3058	·9	5610·01	420189·749
4417·8750	235·6200	75 *in.*	5625	421875
4429·6638	235·9341	·1	5640·01	423564·751
4432·6135	236·0127	·125	5643·76	423987·890
4441·4684	236·2483	·2	5655·04	425259·008
4447·3745	236·4054	·25	5662·56	426107·828
4453·2886	236·5624	·3	5670·09	426957·777
4462·4260	236·7981	·375	5681·390	428234·816
4465·1246	236·8766	·4	5685·16	428661·064
4476·9763	237·1908	·5	5700·25	430368·875
4488·8437	237·5049	·6	5715·36	432081·216
4491·8130	237·5835	·625	5719·14	432510·007
4500·7268	237·8191	·7	5730·49	433798·093

TABLE VII.

Area.	Circum.	Diam.	Square.	Cube.
4506·6742	237·9762	75·75	5738·06	434658·234
4502·6256	238·1332	·8	5745·64	435519 512
4521·5600	238 3689	·875	5757·01	436813·558
4524·5401	238·4474	·9	5760·81	437245·479
4536·4704	238·7616	76 *in.*	5776	438976
4548·4163	239·0757	·1	5791·21	440711·081
4551·4023	239·1543	·125	5795·01	441145·564
4560·3787	239·3899	·2	5806·44	442450·728
4566·2626	239·5470	·25	5814·06	443322·265
4572·3553	239·7040	·3	5821·69	444194·947
4581·3486	239·9397	·375	5833·14	445506·113
4584·3583	240·0182	·4	5836·96	445943·744
4596·3571	240·3324	·5	5852·25	447697·125
4608·3816	240·6465	·6	5867·56	449455·456
4611·3902	240·7251	·625	5871·19	449895·304
4620·4218	240·9607	·7	5882·89	451217·663
4626·4477	241·1178	·75	5890·56	452100·671
4632·4776	241·2748	·8	5898·24	452984·832
4641·5299	241·5105	·875	5909·76	454313·230
4644·5492	241·5987	·9	5913·61	454756·609
4656·6366	241·9032	77 *in.*	5929	456533
4668·7396	242·2173	·1	5944·41	458314·011
4671·7678	242·2959	·125	5948·26	458759·984
4680·8583	242·5315	·2	5959·84	460099·648
4686·9215	242·6886	·25	5967·56	460994·203
4692·9927	242·8456	·3	5975·29	461889·917
4702·1039	243·0813	·375	5986·89	463235·660
4705·1429	243·1598	·4	5990·76	463684·824
4717·3087	243·4740	·5	6006·25	465484·375
4729·4903	243·7881	·6	6021·76	467288·576
4732·5381	243·8667	·625	6025 64	467740·351
4741·6875	244·1023	·7	6037·29	469097·433
4747·7920	244·2594	·75	6045·06	470003·609
4753·9615	244·4164	·8	6052·84	470910·952
4763·0705	244·6521	·875	6064·51	472274·152
4766·1292	244·7316	·9	6068·41	472729·139
4778·3736	245·0448	78 *in.*	6084	474552
4790·6336	245·3589	·1	6099·61	476379·541
4793·7012	245·4375	·125	6103·51	476837·156
4802·9094	245·6731	·2	6115·24	478211·768
4809·0512	245·8302	·25	6123·06	479129·640
4815·2010	245·9872	·3	6130·89	480048·687
4824·4299	246·2229	·375	6142·64	481429·457
4827·5082	246·3014	·4	6146·56	481890·304
4839·8311	246·6156	·5	6162·25	483736·625
4852·1697	246·9297	·6	6177·96	485587·656
4855·2568	247·0083	·625	6181·89	486051·148
4864·5241	247·2439	·7	6193·69	487443·403
4870·7071	247·4010	·75	6201·56	488373·047
4876·8973	247·5480	·8	6209·44	489303·872

TABLE VII.

Area.	Circum.	Diam.	Square.	Cube.
4886·1820	247·7937	78·875	6221·26	490702·324
4889·2799	247·8722	·9	6225·21	491169·069
4901·6814	248·1864	79 *in.*	6241	493039
4914·0985	248·5005	·1	6256·81	494913·671
4917·2053	248 5791	·125	6260·76	495383·078
4926·5314	248·8147	·2	6272·64	496793·088
4932·7517	248·9708	·25	6280·56	497734·578
4938·9820	249·1288	·3	6288·49	498677·257
4948·3268	249·3645	·375	6300·39	500093·504
4951·4443	249·4430	·4	6304·36	500566·184
4963·9243	249·7572	·5	6320·25	502509·875
4976·4840	250·0713	·6	6336·16	504358·336
4979·5456	250·1499	·625	6340·14	504833·695
4988 9314	250·3855	·7	6352·09	506261·573
4995·1931	250·5426	·75	6360·06	507214·992
5001·4586	250·6996	·8	6368·04	508169·592
5010·8642	250·9353	·875	6380·01	509603·746
5014·0014	251·0138	·9	6384·04	510082·399
5026·5600	251·3280	80 *in.*	6400	512000
5039·1342	251·6241	·1	6416·01	513923·401
5042·2803	251·7207	·125	6420·01	514403·750
5051·7242	251·9563	·2	6432·04	515849·608
5058 0230	252·1134	·25	6440·06	516815 016
5064·3298	252·2704	·3	6448·09	517781·627
5073·7944	252· 061	·375	6460·14	519233·801
5076·9552	252 5846	·4	6464·16	519718·464
5089·5883	252·8988	·5	6480·25	521660·125
5102·2411	253·2129	·6	6496·36	523606·616
5105·4060	253·2915	·625	6500·39	524093·992
5114·9096	253·5271	·7	6512·49	525557·943
5121·2497	253·6842	·75	6520·56	526535·422
5127·5938	253 8412	·8	6528·64	527514·112
5137·1173	254·0769	·875	6540·76	528984·418
5140·2937	254·1554	·9	6544·81	529475·129
5153·0094	254·4696	81 *in.*	6561	531441
5165·7407	254·7837	·1	6577·21	533411·731
5168·9260	254·8623	·125	6581·26	533903·172
5178 4877	255 0979	·2	6593·44	535387·328
5184·8651	255·2550	·25	6601·56	536376·953
5191·2505	255·4120	·3	6609·69	537367·797
5200·8329	255·6477	·375	6621·89	538856·347
5204·0285	255·7262	·4	6625 96	539353·144
5216·8231	256·0404	·5	6642·25	541343·375
5229·6330	256·3545	·6	6658·56	543338·496
5232·8371	256·4331	·625	6662·64	543838·029
5242·4586	256·6687	·7	6674·89	545338·513
5248·8772	256·8258	·75	6683·06	546340·359
5255·2998	256·9828	·8	6691·24	547343·432
5264·9411	257·2105	·875	6703·51	548850·339
5268·1568	257·2970	·9	6707·61	549353·259

TABLE VII.

Area.	Circum.	Diam.	Square	Cube.
5281·0296	257·6112	82 *in.*	6724	551368
5293·9180	257·9253	·1	6740·51	553387·661
5297·1426	258·0039	·125	6744·51	553863·343
5306·8221	258·2395	·2	6756·84	555412·248
5313·2780	258·3966	·25	6765·06	556426·390
5319·7439	258·5536	·3	6773·29	557441·767
5329·4421	258·7893	·375	6785·64	558967·144
5332·6775	258·8646	·4	6789·76	559476·224
5345·6287	259·1820	·5	6806·25	561515·625
5358·5957	259·4961	·6	6822·76	563559·976
5361·8391	259 5747	·625	6826·89	564071·836
5371·5983	259·8103	·7	6839·29	565609·283
5378·0755	259·9674	·75	6847·56	566635·797
5384·5762	260·1244	·8	6855·84	567663·552
5394·3358	260·3601	·875	6868·26	569207·511
5397·5908	260·4386	·9	6872·41	569722·789
5410·6206	260·7528	83 *in.*	6889	571787
5423·6660	261·0669	·1	6905·61	573856·191
5426·9299	261·1455	·125	6909·76	574374·265
5436·7272	261·3811	·2	6922·24	575930·368
5443·2617	261·5382	·25	6930·56	576969·328
5449·8042	261·6952	·3	6938·89	578009·537
5459·6222	261·9309	·375	6951·39	579572·191
5462·8968	262·0094	·4	6955·56	580093·704
5476·0051	262·3236	·5	6972·25	582182·875
5489·1291	262·6376	·6	6988·96	584277·056
5492·4118	262·7163	·625	6993·14	584801·382
5502·2689	262·9519	·7	7005·69	586376·253
5508·8446	263·1090	·75	7014·06	587427·734
5515·4243	263·2640	·8	7022·44	588480·472
5525·3012	263·5057	·875	7035·01	590061·933
5528·5958	263·5802	·9	7039·21	590589·719
5541·7024	263·8944	84 *in.*	7056	592304
5554·9849	264·2085	·1	7072·81	594823·321
5558·2881	264·2871	·125	7077·01	595353·937
5568·2032	264·5227	·2	7089·64	596947·688
5574·8162	264·6798	·25	7098·06	598011·765
5581·4372	264·8368	·3	7106·49	599077·107
5591·3730	265·0725	·375	7119·14	600677·498
5594·6869	265·1510	·4	7123·36	601211·584
5607·9523	265·4652	·5	7140·25	603351·125
5621·2334	265·7793	·6	7159·16	605495·736
5624·5554	265·8579	·625	7161·39	606032·679
5634·5682	266·0935	·7	7174·09	607645·423
5641·1845	266·2506	·75	7182·56	608722·172
5647·8428	266·4076	·8	7191·04	609800·192
5657·8357	266·6433	·875	7203·76	611419·605
5661·1710	266·7218	·9	7208·11	611960·049
5674·5150	267·0360	85 *in.*	7225	614125
5687·8746	267·3501	·1	7242·01	616295·051

TABLE VII.

Area.	Circum.	Diam.	Square.	Cube.
5691·2170	267·4287	85·125	7246·26	616838·359
5701·2500	267·6643	·2	7259·04	618470·208
5707·9415	267·8214	·25	7267·56	619559·703
5714·6410	267·9784	·3	7276·09	620650·477
5724·6947	268·2141	·375	7288·89	622289·035
5728·0478	268·2926	·4	7293·16	622835·864
5741·4703	268·6068	·5	7310·25	625026·375
5754·9185	268·9209	·6	7327·36	627222·016
5758 2697	268·9997	·625	7331·64	627771·726
5768·3624	269·2350	·7	7344·49	629422·793
5775·0952	269·3922	·75	7353·06	630525·109
5781·8320	269·5492	·8	7361·64	631628·712
5791·9445	269·7849	·875	7374·51	633286·527
5795·3173	269·8634	·9	7378·81	633839·779
5808·8184	270·1776	86 *in.*	7396	636056
5822·3351	270·4917	·1	7413·21	638277·381
5825·7168	270·5703	·125	7417·51	638833·531
5835·8675	270·8059	·2	7430·44	640503·928
5842·6376	270·9630	·25	7439·06	641619·140
5849·4157	271·1200	·3	7447·69	642735·647
5859·5871	271·3557	·375	7460·64	644412·832
5862·9795	271·4342	·4	7464·96	644972·544
5876·5591	271·7484	·5	7482·25	647214·625
5890·1541	272 0665	·6	7499·56	649461·896
5893·5549	272·1411	·625	7503·89	650024·523
5903·7654	272·3767	·7	7516·89	651714·263
5910·5767	272·5338	·75	7525·56	652842·547
5917·3920	272·6908	·8	7534·24	653912·032
5927·6224	272·9265	·875	7547·26	655668·699
5931·0344	273·0050	·9	7551·61	656234·909
5944·6926	273·3190	87 *in.*	7569	658503
5958·3644	273·6333	·1	7586·41	660776·311
5961·7873	273·7119	·125	7590·76	661345·453
5972·0559	273·9875	·2	7603·84	663054·818
5978·9045	274·1046	·25	7612·56	664196·078
5985·7691	274·2616	·3	7621·29	665338·617
5996·0504	274·4973	·375	7634·39	667054·878
5999·4821	274·5758	·4	7638 76	667627·624
6013·2187	274·8900	·5	7656·25	669921·875
6026·9711	275·2041	·6	7673·76	672221·376
6030·4108	275·2827	·625	7678·14	672797·070
6040·7391	275·5183	·7	7691·29	674526 133
6047·6290	275·6754	·75	7700·06	675680·484
6054·5149	275·8324	·8	7708 84	676836·152
6064·8710	276·0681	·875	7722·01	678572·121
6068·3224	276·1466	·9	7726·41	679151·439
6082·1376	276·4608	88 *in.*	7744	681472
6095·9684	276·7749	·1	7761·61	683797·841
6099·4287	276·8535	·125	7766·01	684380·125
6109·8150	277·0891	·2	7779·24	686128·968

TABLE VII.

·Area.	Circum.	Diam.	Square.	Cube.
6116·7422	277·2462	88·25	7788·06	687296·516
6123·6774	277·4032	·3	7796·89	688465·387
6134·0844	277·6389	·375	7810·14	690221·175
6137·5554	277·7174	·4	7814·56	690807·104
6151·4491	278·0316	·5	7832·25	693154·122
6165·5585	278·3457	·6	7849·96	695506·456
6169·8376	278·4243	·625	7854·39	696095·367
6179·2837	278·6599	·7	7867·69	697864·103
6186·2521	278·8170	·75	7876·56	699044·922
6193·2245	278·9750	·8	7885·44	700227·072
6203·6905	279·2097	·875	7898·76	702002·793
6207·1811	279·2882	·9	7903·21	702955·369
6221·1534	279·6024	89 *in.*	7921	704969
6235·1413	279·9165	·1	7938·81	707349·971
6238·6408	279·9951	·125	7943·26	707943·547
6249·1450	280·2307	·2	7956·64	709732·288
6256·1507	280·3878	·25	7965·56	710926·453
6263·1644	280·5448	·3	7974·49	712121·957
6273·6893	280·7805	·375	7987·89	713907·722
6277·1995	280·8590	·4	7992·36	714516·984
6291·2035	281·1732	·5	8010·25	716917·375
6305·3168	281·4873	·6	8028·16	719232·136
6308·8351	281·5659	·625	8032·64	719925·414
6319·3990	281·8825	·7	8046·09	721734·273
6326·4460	281·9586	·75	8055·06	723051·859
6333·4970	282·1156	·8	8064·04	724150·792
6344·0847	282·3513	·875	8077·51	725966·714
6347·6813	282·4298	·9	8082·01	726572 699
6361·7400	282·7440	90 *in.*	8100	729000
6375·8850	283·0581	·1	8118·01	731432·701
6379·4238	283·1367	·125	8122·51	732041·718
6390·0458	283·2733	·2	8136·04	733870·808
6397·1300	283·5294	·25	8145·06	735091·890
6404·2222	283·8664	·3	8154·09	736314·327
6414·8649	283·9221	·375	8167·64	738150·519
6418·4144	284·0006	·4	8172·16	738763·264
6432·6223	284·3148	·5	8190·25	741217·625
6446·8474	284·6289	·6	8208·36	743677·416
6450·4039	284·7075	·625	8212·89	744293·210
6461·0852	284·9431	·7	8226·49	746142·643
6468·2107	285·1002	·75	8235·56	747377·297
6475·3402	285·2572	·8	8244·64	748613·312
6486·0418	285·4929	·875	8258·26	750469·886
6489·6109	285·5714	·9	8262·81	751089·429
6503·8974	285·8856	91 *in.*	8281	753571
6518·1995	286·1997	·1	8299·21	756058·530
6521·7775	286·2783	·125	8303·76	756680·640
6532·5173	286·5139	·2	8317·44	758550·528
6539·6801	286·6710	.25	8326·562	759798·828
6546·8909	286·8290	·3	8335·69	761048·497

TABLE VII.

Area.	Circum.	Diam.	Square.	Cube.
6557·6114	287·0637	91·375	8349·39	762925·566
6561·2081	287·1422	·4	8353·96	763551·944
6575·5651	287·4564	·5	8372·25	766060·875
6589·9458	287·7705	·6	8390·56	768575·296
6593·5431	287·8491	·625	8395·14	769204·757
6604·3222	288·0847	·7	8408·89	770915·213
6611·5462	288·2418	·75	8418·06	772357·234
6618·7542	288·3988	·8	8427·24	773620·632
6629·5736	288·6345	·875	8441·01	775518·308
6633·1820	288·7130	·9	8445·61	776151·559
6647·6256	289·0272	92 *in.*	8464	778688
6662·1848	289·3413	·1	8482·41	781229·961
6665·7021	289·4199	·125	8487·01	781866·312
6676·5597	289·6555	·2	8500·84	783777·448
6683·8010	289·8125	·25	8510·06	785053·265
6691·0161	289·9696	·3	8519·29	786330·467
6701·9286	290·2053	·375	8533·14	788248·863
6705·5567	290·2838	·4	8537·76	788889·024
6720·0787	290·5980	·5	8556·25	791453·125
6734·6165	290·9120	·6	8574·76	794022·776
6738·2530	290·5907	·625	8579·39	794666·054
6749·1699	291·2263	·7	8593·29	796597·983
6756·4525	291·3834	·75	8602·56	797887·672
6763·7391	291·5404	·8	8611·84	799178·752
6774·6763	291·7761	·875	8625·76	801117·980
6778·3240	291·8546	·9	8630·41	801765·085
6792·9246	292·1688	93 *in.*	8649	804357
6807·5408	292·4829	·1	8667·61	807964·491
6811·1974	292·5615	·125	8672·26	807604·734
6822·1730	292·7971	·2	8686·24	809557·568
6829·4927	292·9542	·25	8695·56	810861·203
6836·8206	293·1112	·3	8704·89	812166·237
6847·8167	293·3469	·375	8718·89	814126·410
6851·4840	293·4354	·4	8723·56	814780·504
6866·1631	293·7396	·5	8742·25	817400·375
6880·8579	294·0537	·6	8760·96	820025·856
6884·5338	294·1323	·625	8765·64	820683·101
6895·5685	294·3679	·7	8779·69	822656·953
6902·3497	294·5350	·75	8789·06	823974·902
6910·2947	294·6820	·8	8798·44	825293·672
6921·3336	294·9170	·875	8812·51	827274·906
6925·0367	294·9962	·9	8817·21	827936·019
6939·7944	295·3104	94 *in.*	8836	830584
6954·5677	295·6245	·1	8854·81	833237·621
6958·2473	295·7024	·125	8859·51	833901·908
6969·3568	295·9387	·2	8873·64	835896·386
6976·7410	296·0951	·25	8883·06	837228·640
6984·1614	296·2436	·3	8892·49	838561·807
6995·2755	296·4739	·375	8906·64	840564·208
6998·9821	296·5670	·4	8911·36	841232·384

TABLE VII.

Area.	Circum.	Diam.	Square.	Cube.
7013·8183	296·8812	94·5	8930·25	843908·625
7028·6702	297·1953	·6	8949·16	846590·536
7032·3853	297·2739	·625	8953·89	847261·898
7043·5025	297·5095	·7	8968·09	849278·123
7050·9775	297·6666	·75	8977·56	850264·047
7058·4180	297·8236	·8	8987·04	851971·392
7069·5940	298·0593	·875	9001·26	853995·074
7073·3202	298·1378	·9	9006·01	854670·349
7088·2350	298·4520	95 *in.*	9025	857375
7103·1654	298·7661	·1	9044·01	860885·351
7106·9005	298 8447	·125	9048·76	860763·828
7118·1116	299·0723	·2	9063·04	862801·408
7125·5885	299·2374	·25	9072·56	864161·578
7133·0734	299·3944	·3	9082·09	865523·177
7144·3052	299·6301	·375	9096·39	867568·253
7148·0510	299·7086	·4	9101·16	868250·664
7163·0443	300·0228	·5	9120·25	870983·875
7178·0533	300·3369	·6	9139·36	873722·816
7181·8077	300·4155	·625	9144·14	874408·445
7193·0780	300·6511	·7	9158·49	876467·493
7200·5962	300·8082	·75	9168·06	877841·984
7208·1184	300·9652	·8	9177·64	879217·912
7219·4090	301·2009	·875	9192·01	881284·495
7223·1745	301·2794	·9	9196·81	881974·079
7238·2464	301·5936	96 *in.*	9216	884736
7253·3339	301·9077	·1	9235·21	887503·681
7257·1083	301·9863	·125	9248·01	888965·499
7268·4371	302·2219	·2	9254·44	890277·128
7275·9926	302·3790	·25	9264·06	891666·015
7283·5561	302·5360	·3	9273·69	893056·347
7294·9056	302·7717	·375	9288·14	894944·550
7298·6917	302·8502	·4	9292·96	895841·344
7313·8411	303·1644	·5	9312·25	898632·125
7329·0072	303·4785	·6	9331·56	901428·696
7332·8008	303·5571	·625	9336·39	902128·742
7344·1890	303·7927	·7	9350·89	904231·063
7361·2873	303·9498	·75	9360·56	905634·422
7359·3864	304·1068	·8	9370·24	907039·232
7370·7949	304·3425	·875	9384·76	909149·167
7374·5996	304 4210	·9	9389·61	909853·209
7389·8286	304·7352	97 *in.*	9409	912673
7405·0732	305·0493	·1	9428·41	915498·611
7408·8868	305·1279	·125	9433·26	916205·921
7420·3335	305·3635	·2	9447·84	918330·048
7427·9675	305·5206	·25	9457·56	919747·953
7435·6095	305·6776	·3	9467·29	921167·317
7447·0769	305·9133	·375	9481·89	923299·097
7450·9013	305·9918	·4	9486·76	924010·424
7466·2087	306·3060	·5	9506·25	926859·375
7481·5319	306·6201	·6	9525·76	929714·176

TABLE VII.

Area.	Circum.	Diam.	Square.	Cube.
7458·3648	306·6987	97·625	9530·640	930428·788
7496·8706	306·9363	·7	9545·29	932574·833
7504·5468	307·0914	·75	9555·06	934007·359
7512·2253	307·2484	·8	9564·84	935441·352
7523·7515	307·4841	·875	9579·51	937595·089
7527·5956	307·5626	·9	9584·41	938313·739
7542·9816	307·8768	98 *in.*	9604	941192
7558·3832	308·1909	·1	9623·61	944076·141
7562·2362	308·2695	·125	9628·51	944789·093
7573·8006	308·5051	·2	9643·24	946966·168
7581·5132	308·6662	·25	9653·06	948413·390
7589·2338	308·8192	·3	9662·89	949862·087
7600·8189	309·0549	·375	9677·64	952037·894
7604·6826	309·1334	·4	9682·56	952763·904
7620·1471	309·4476	·5	9702·25	955671·625
7635·6273	309·7617	·6	9720·06	958858·256
7639·4995	309·8403	·625	9726·89	959314·585
7651·1933	310·0759	·7	9741·69	961504·803
7658·8771	310·2330	·75	9751·56	962966·797
7666·6349	310·3960	·8	9761·44	964430·272
7678·2790	310·6257	·875	9776·26	966628·261
7682·1623	310·7042	·9	9781·21	967361·669
7697·7054	311·0184	99 *in.*	9801	970299
7713·2641	311·3325	·1	9820·81	973242·271
7717·1563	311·4111	·125	9825·76	973979·015
7728·8386	311·6467	·2	9840·54	976911·488
7736·6297	311·8038	·25	9850·56	977688·328
7744·4288	311·9608	·3	9860·49	979146·657
7756·1318	312·1965	·375	9875·39	981366·941
7760·0347	312·2750	·4	9880·36	982107·784
7775·6563	312·5892	·5	9900·25	985074·875
7791·2936	312·9033	·6	9920·16	988047·936
7795·2051	312·9819	·625	9925·14	988792·132
7806·9466	313·2175	·7	9940·09	991026·973
7814·7790	313·3746	·75	9950·06	992518·734
7822·6054	313·5116	·8	9960·04	994011·992
7834·3772	313·7630	·875	9975·01	996254·683
7838·2998	313·8458	·9	9980·01	997022·999
7854·0000	314·1600	100 *in.*	10000	1000000

A concise Method of Verifying Dates, in accordance with the Julian and Gregorian Calendars; or for Finding the Day of the Week, corresponding to any proposed Date of the Month after Christ, without limitation.

By SAMUEL MAYNARD, Editor of Keith's and Bonnycastle's Mathematical Works, &c. &c.

Directions for using the table.—If the given date be Old Style and less than 700 years, or New Style and less than 400 years, it will be the tabular date for its respective style; but if the date be Old Style and 700 or more, or New Style and 400 or more, divide by 700 or 400 respectively, the remainder in either case will be the tabular date, these remaining centuries will he found in the upper part of the table, under the title, "Remainders *only* of given Centuries," &c., against **O. S.** for Old Style, and **N. S.** for New Style, and the remaining years will be found on the left hand of the table under the title "Remaining years of given Date less than one hundred," and the Literal Index for the given date will be found in the same horizontal line, in the first vertical column of letters; enter this Literal Index in the vertical column under the tabular Century or Centuries just found, then find on the same horizontal line the given month, directly over which, in the same vertical column, and on the same horizontal line with the day of the month, will be found the day of the week required.

If the Dominical letter of the given date is required, find the literal index as before directed, which enter as before under the column of centuries, then in the same horizontal line, in the first vertical column of letters, will be found the Dominical letter required.

The years which are dotted are Leap Years, except the secular tabular dates 100, 200, 300, New Style, which are common years; and for *January* and *February* in leap years take **J** and **F** respectively.——

Note.—A Cycle of the Julian Calendar is 700 *years*, and that of the Gregorian 400 *years*; and on this principle the above table has been constructed.

Remainders *only* of given Centuries, together with their Literal Indexes and Dominical Letters.

Remaining years of given date less than one hundred	O. S.	5	6	0	1	2	3	4
	N. S.	0		1		2		3

0	6		17	23	·28	34		45	51	·56	62		73	79	·84	90		A	G	F	E	D	C	B	January October	May	**F**. Aug.	Feb. Mar November	June	S ptember December	**J**. April July	Months, days of the month, and days of the week corresponding.
1	7	·12	18		29	35	·40	46		57	63	·68	74		85	91	·96	G	F	E	D	C	B	A	**J**. April July	January October	May	**F**. Aug.	Feb. Mar. November	June	September December	
2		13	19	·24	30		41	47	·52	58		69	75	·80	86		97	F	E	D	C	B	A	G	September December	**J**. April July	January October	May	**F**. Aug.	Feb. Mar. November	June	
3	·8	14		25	31	·36	42		53	59	·64	70		81	87	·92	98	E	D	C	B	A	G	F	June	September December	**J**. April July	January October	May	**F**. Aug.	Feb. Mar. November	
	9	15	·20	26		37	43	·48	54		65	71	·76	82		93	99	D	C	B	A	G	F	E	Feb. Mar. November	June	September December	**J**. April July	January October	May	**F**. Aug.	
·4	10		21	27	·32	38		49	55	·60	66		77	83	·88	94		C	B	A	G	F	E	D	**F**. Aug.	Feb. Mar. November	June	September December	**J**. April July.	January October	May	
5	11	·16	22		33	39	·44	50		61	67	·72	78		89	95		B	A	G	F	E	D	C	May	**F**. Aug.	Feb. Mar. November	June	September December	**J**. April July	January October	

Sunday	*Monday*	*Tuesday*	*Wednes.*	*Thursd.*	*Friday*	*Saturday*	1	8	15	22	29
Monday	*Tuesday*	*Wednes.*	*Thursd.*	*Friday*	*Saturday*	*Sunday*	2	9	16	23	30
Tuesday	*Wednes.*	*Thursd.*	*Friday*	*Saturday*	*Sunday*	*Monday*	3	10	17	24	31
Wednes.	*Thursd.*	*Friday*	*Saturday*	*Sunday*	*Monday*	*Tuesday*	4	11	18	25	
Thursd.	*Friday*	*Saturday*	*Sunday*	*Monday*	*Tuesday*	*Wednes.*	5	12	19	26	
Friday	*Saturday*	*Sunday*	*Monday*	*Tuesday*	*Wednes.*	*Thursd.*	6	13	20	27	
Saturday	*Sunday*	*Monday*	*Tuesday*	*Wednes.*	*Thursd.*	*Friday*	7	14	21	28	

EXAMPLES FOR PRACTICE ON THE PRECEDING TABLE.

(1.) Find the Dominical letter for the year 1727, Old Style. Here, 1727 ÷ 700 leaves a remainder of 327 years, that is, **3** centuries and 27 years; then, on the same horizontal line with 27 at the left hand of the table, among the "Remaining years of the given date less than one hundred," and opposite the 27 in the first vertical column of letters will be found the Literal Index **C**; enter this **C** in the vertical column under **3. O. S.** (**3** being the number of centuries of the tabular date 327), it will be found on the top line of letters under its respective tabular centuries; then, on the same horizontal line, in the first vertical column of letters will be found **A**, the Dominical letter required.

(2.) Required the day of the week; 1*st* of January, 1800, and 12*th* of *February*, 1852, New Style in both cases?*

Here, 1800 ÷ 400 leaves a remainder of 200 years, that is, **2** centuries and 0 years, which denotes a common year, on the line of 0 in the table; the years less than one hundred will be found as in *Ex.* 1, the Literal Index **A**, enter this Index **A** under the tabular centuries **2, N. S.**, and it will be found on the fourth line of letters; then, on the same horizontal line, in the fourth vertical column of months will be found the given month, January (along with October), over which, in the same column and on the same horizontal line with 1, the given day of the month, will be found Wednesday, the day of the week required. Again, for 1852, we have 1852 ÷ 400, remainder 252, and ·52 in the table gives as above the Literal Index **F**, this Index **F** will be found again on the last line but one of letters in column **2, N. S.**, the given year being a leap year: proceed on this horizontal line to the first vertical column of months, where will be found **F**, (along with August,) *viz. February*, leap year, the given month; then, as in the preceding case, will be found Thursday, the day of the week required.

(3.) Required the days of the week **N. S.** corresponding to the dates of the following registrations:—Samuel was born December 16*th*, 1789; Hannah on 14*th* July, 1791; Rebecca on 11*th* October, 1800; Ann on 25*th* December, 1813; Alfred, on 23*rd* February, 1821: Augustus on 20*th* May, 1823; Sarah on 30*th* January, 1826; Newton on 6*th* December, 1832; and Mary Ann on 26th December, 1834.

Ans. Samuel on a Wednesday; Hannah on a Thursday; Rebecca on a Saturday; Ann on a Saturday; Alfred on a Friday; Augustus on a Tuesday; Sarah on a Monday; Newton on a Thursday; and Mary Ann on a Friday.

(4.) What day of the month did the last Friday in *January*, *February*, August, and December fall on in the year 1844, **N. S.**?

Ans. 26*th* of *January*, 23*rd* of *February*, 30*th* of August, and 27*th* of December.

(5.) An elderly lady, speaking of her age, says, she was born in the year 1760, **N. S.**, but does not know on what day of the month; she only recollects hearing her father say it was the second Wednesday in *February;* required the day of the month she was born? *Ans.* 13*th*.

(6.) In what years of the 19*th* century, New Style, does 29*th* of *February* fall on a Friday, being leap years?

Look in the table for 29, the given day of the month, and on the same horizontal line find Friday, the given day of the week; in the

* The New Style was first introduced into Rome by Pope Gregory XIII., on October 15th, 1582; and into the British Dominions by Act of Parliament, September 14th, 1752.

same vertical column find **F**, the given month, *viz. February*, leap year then, in the same horizontal line, and in the vertical column of **2**, **N. S.**, will be found **A**, the Literal Index of the given year; enter this Index **A** in the first vertical column of letters, then, on the same horizontal line, will be found the years of the required dates less than one hundred, selecting only the leap years, *viz.* those which are dotted, we have ·0, ·28, ·56, ·84, whence we take 1800, 1828, 1856, 1884; however, 1800 being a common year must be excluded; and were it even a leap year, it would have been excluded, since it is not in the 19*th* century, which does not commence before 1*st* January, 1801. Hence, 1828, 1856, 1884 are the years required.

(7.) In what years of the 19*th* century, New Style, does Midsummer Day (24*th* June) fall on a Sunday?

Ans. 1804, 1810, 1821, 1827, 1832, 1838, 1849, 1855, 1860, 1866, 1877, 1883, 1888, and 1894.

(8.) Required the Dominical letters, for leap years and common years, when the 1*st* of January and February fall on a Sunday?

Find 1, the day of the month in the table, and on the same horizontal line find Sunday, the day of the week; in the same vertical column find **J**, for *January*, leap year; then, in the same horizontal line, in the *first* vertical column of letters will be found **G**, the Dominical letter required; similarly for January, in common years, will be found **A**, the required Dominical letter; similarly for **F**, or *February*, leap year, will be found the Dominical letter **C**, and for February, common years, the Dominical letter will be **D**.

(9.) On what days of the week in the year 1724, Old Style, did 17*th* of *January*, leap year, and 16th December, fall? and in what other years of the 18*th* and 19*th* centuries will the same days of the month fall on the same days of the week?

Ans. In the year 1724, **O. S.**, 17*th* of *January* happened on a Friday, and 16*th* December on a Wednesday. There is but one other leap year, **O. S.**, *viz.* 1752, which in the 18*th* century answers the question, and only one leap year, **N. S.**, in the 18*th* century, *viz.* 1772; similarly, in the 19*th* century **N. S.**, the leap years required are 1812, 1840, 1868, and 1896; in all these instances 17*th* *January* falls on a Friday.

With regard to 16*th* December, all years before 1752 are to be taken by Old Style; these years are 1702, 1713, 1719, 1724, 1730, 1741, and 1747, **O. S.**; the years after 1751 are to be taken by New Style, which, in the 18*th* century, are 1761, 1767, 1772, 1778, 1789, and 1795. In the 19*th* century the years are 1801, 1807, 1812, 1818, 1829, 1835, 1840, 1846, 1857, 1863, 1868, 1874, 1885, 1891, and 1896, in all which cases 16*th* December falls on a Wednesday.

N.B. Those who may be desirous of acquainting themselves with further particulars on the perpetuity of the Civil and Ecclesiastical Calendars, may with advantage consult Bonnycastle's Arithmetic and Key, by *Samuel Maynard*, *Edition* 1851, and Key, 1852, and all subsequent editions.

THE END.

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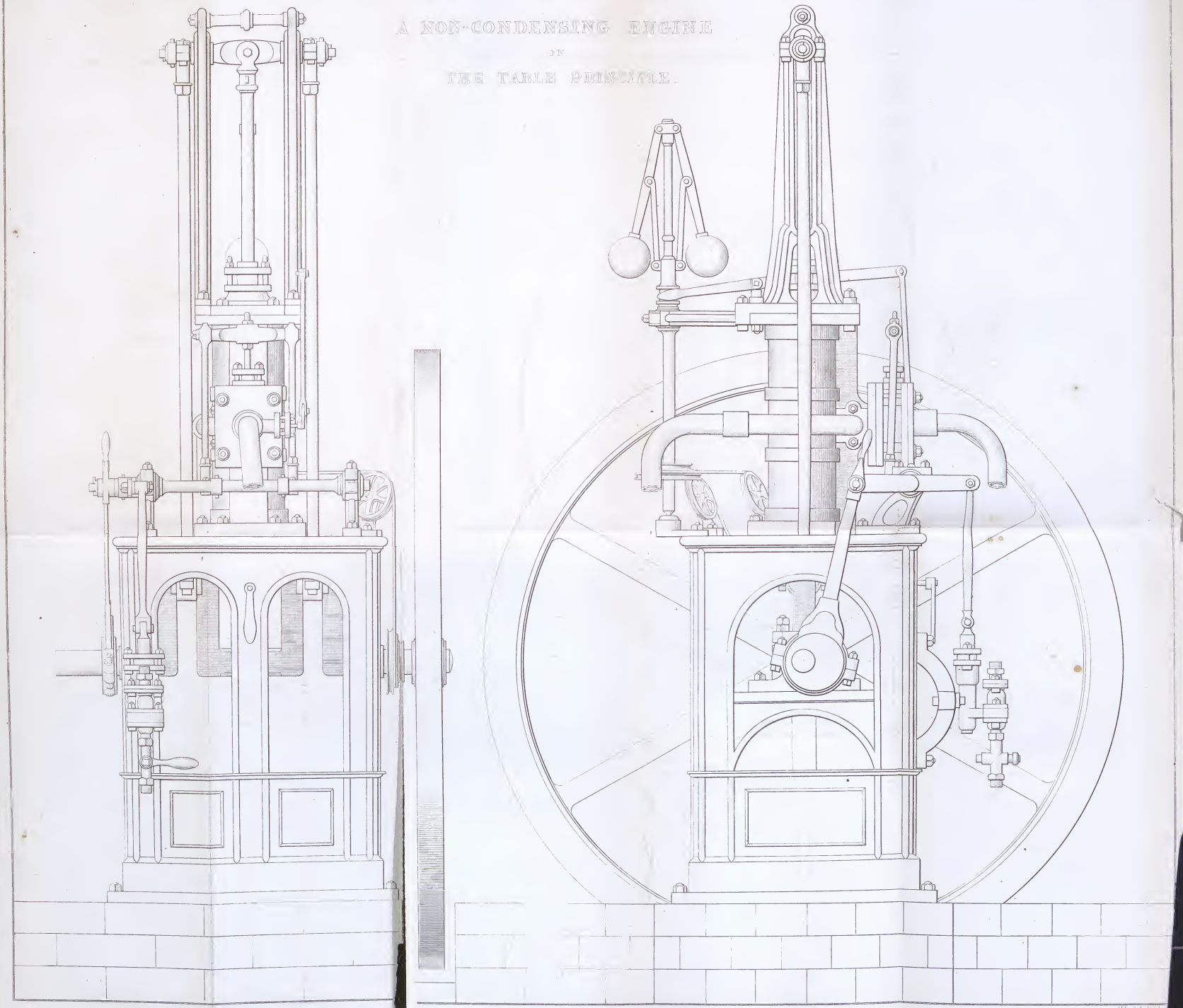

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